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REPORT

OF THE

SECRETARY OF WAR;

BEING PART OF

THE MESSAGE AND DOCUMENTS

COMMUNICATED TO THE

TWO HOUSES OF CONGRESS

AT THE

BEGINNING OF THE SECOND SESSION OF THE FORTY-EIGHTH CONGRESS.

IN FOUR VOLUMES.

VOLUME II.

PART 4.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1884.

APPENDIXES

TO THE

REPORT OF THE CHIEF OF ENGINEERS,

UNITED STATES ARMY.

(CONTINUED.)

APPENDIX T T.

MISSISSIPPI RIVER COMMISSION.

To the Senate and House of Representatives:

I transmit herewith to the House of Representatives a communication from the Secretary of War submitting the annual report of the Mississippi River Commission.

I take this occasion to invite the early attention of Congress to the continuation of the work on the Mississippi River, which is being carried on under the plans of the Commission. My sense of the importance of the improvement of this river, not only to the people of the Northwest, but especially to the inhabitants of the Lower Mississippi Valley, has already been expressed in a special communication to the last Congress. The harvests of grain and cotton produced in the region bordering upon the Mississippi are so vast as to be of national importance, and the project now being executed for their cheap transportation should be sufficiently provided for.

The Commission report that the results due to the still uncompleted works have been remarkable, and give the highest encouragement for expecting the ultimate success of the improvement.

The act of August 2, 1882, appropriated $4,123,000 for the work on that part of the river below Cairo. The estimates of the Commission already transmitted to Congress call for $3,000,000 for the continuation of the work below Cairo; and it appears from their report that all of the last appropriation available for active operations has been exhausted, and that there is urgently needed an immediate appropriation of $1,000,000 to continue the work without loss of time, in view of the approach of the flood season with its attendant dangers. I therefore recommend to Congress the early passage of a separate bill on this subject.

CHESTER A. ARTHUR.

EXECUTIVE MANSION, *January* 8, 1884.

LETTER OF THE SECRETARY OF WAR.

WAR DEPARTMENT,
Washington City, January 7, 1884.

SIR: I have the honor to submit herewith, for transmission to Congress, the annual report of the Mississippi River Commission for the year 1883.

Very respectfully, your obedient servant,

ROBERT T. LINCOLN,
Secretary of War.

The PRESIDENT.

REPORT.

THE MISSISSIPPI RIVER COMMISSION,
PRESIDENT'S OFFICE,
New York, December 21, 1882[3].

SIR: The Mississippi River Commission have the honor to submit the following report, embracing the subjects and subdivisions specified below, to wit:

1. Progress of surveys and examinations since December 1, 1882.
2. Construction.
3. Remarks on the subjects of levees and outlets.
4. Legislation.
5. Financial statements and estimates of funds for the fiscal year ending June 30, 1885, for "Surveys and expenses of the Commission" and for "Improving the Mississippi River."

PROGRESS OF SURVEYS AND EXAMINATIONS.

The surveys and examinations, undertaken in pursuance of the requirements of the third section of the organic act, have been continued.

From December 1, 1882, to December 1, 18:3, the following progress is reported:

Gauges.—Daily readings have been continued at the stations maintained by the Commission, and two new gauges, at Gray's Point, Mo., and Columbus, Ky., have been established. This service has been greatly improved during the past year, and its value, both as an aid to navigation and as a source of hydraulic data, greatly enhanced. A small steamer has been purchased and equipped for the duty of maintaining these gauges in correct position, and insuring accuracy of record and display. This boat is constantly passing up and down the river in the performance of this as her principal duty. She visits each gauge at least once a month. The daily readings are conspicuously displayed on bulletin boards, and are now a prominent feature of the records kept by pilots for their mutual information. The bulletins are frequently read at night by means of the electric light.

Triangulation.—No field work has been done during the year. The adjustment and reduction of previous work has been completed.

Precise levels.—The line has been continued northward along the river from Clinton, Iowa, to Savannah, Ill. (22 miles), and thence to Lake Michigan at Chicago (148 miles). The reduction of the part from Clinton to Savannah and also of the remainder of the line from Grafton to Keokuk has been completed.

The record of the tide-gauge on the Gulf of Mexico has been continued. Owing to the considerable discrepancies in the means of different lunations, it has been thought unadvisable to terminate the series, so that the mean Gulf level, upon which all elevations are finally to depend, remains undetermined.

Final topography and hydrography, on the same scale as mentioned in last report, has been completed from 10 miles above Vicksburg to Donaldsonville, a distance of 297 miles; from Island No. 1 to Donaldson's Point, 60 miles; from Caruthersville to Plum Point, 58 miles; from Randolph Point to Memphis, 15 miles; and from Commerce Cut-off to Trotter's Landing, 33 miles, making a grand total of 463 miles of river surveyed during the year.

In connection with this branch of work, occasion was taken to repeat, in the fall of 1882, the cross-sections near the principal crevasses of the preceding flood, for comparison with measurements of the same sections made previous to the flood.

Detail charts (scale of $\frac{1}{10000}$) from Arkansas City to Greenville, and from Lake Providence to Waterproof, comprising 160 miles of river, have been plotted and drawn in the office. In addition, the remaining sheets to Donaldsonville are partially completed. The preparation of the preliminary chart (one inch to a mile) has been continued, five sheets, extending to Rodney, Miss., having been drawn, and five sheets, extending to the foot of Island 97, published.

Trans-alluvial levels.—The system of lines undertaken, as noted in the Report of the Commission for 1881, p. 3, to obtain information as to the heights of the alluvial bottom lands and their reservoir capacity, was completed during the past year.

Other work in the same direction, consisting of 160 miles of levels in the country between Lower Red River and the Atchafalaya, has been completed.

Observations.—The series of measurements at Paducah, Columbus, Helena, Hays' Landing, and Red River Landing, which closed in December, 1882, have been reduced. The measurements of escape through crevasses and otherwise were repeated for the flood of 1883, which was, at Cairo, the highest on record. This work was not continued below Vicksburg, since at that point the flood was several feet below that of 1882, and was no longer of unusual magnitude.

High-water marks and slope.—The collection of reliable high-water marks of 1883, and previous years, has been continued. The profile of the water surface was determined for the low water of October, 1883, from Saint Louis to New Orleans.

A financial statement and an itemized statement of the expenditure of the appropriation in act of August 2, 1882, appear below.

The following papers relating to the work of surveys and examinations are submitted as appendices to this report:

Appendix A.—Annual report of the secretary of the Commission upon the field work of surveys and examinations.

Appendix B.—Report upon, and final results of, secondary triangulation from Cairo to Keokuk.

Appendix C.—Report upon, and results of, precise leveling from Carrollton to Biloxi, and from Cairo to Fulton.

Appendix D.—Reports upon field work of topography and hydrography.

Appendix E.—Report upon the work of trans-alluvial leveling, with profiles of the lines.

Appendix F.—Reports upon and results, of observations of river discharge at various points.

Appendix G.—Report upon changes of the Mississippi River, as shown by comparison of the earliest and latest authentic surveys.

CONSTRUCTION.

At the date of the last annual report of the Commission, December 1, 1882, work had been fairly inaugurated on the Plum Point and Lake Providence Reaches, and also in the vicinity of Memphis and Vicksburg, and throughout December and January the work was pushed with great vigor. Unfortunately the extremely cold weather interfered seriously with the stone supply from the Ohio and Upper Mississippi, the running ice at times entirely cutting off access to the quarries. As a consequence of this there was a large accumulation of mattress work, both for bank revetment and for pile-dike foot mats, which was afloat in place, but unsunk for lack of stone. In this condition of affairs, early in February the river began to rise rapidly, bringing down great quantities of drift, while the heavy running ice on the Mississippi and Ohio still prevented the procuring of an adequate supply of stone. Efforts were made to use sacks of sand instead, but without much success, and at both Plum Point and Lake Providence a considerable amount of mattress work was lost. At the former place the uncompleted pile dikes also suffered considerable damage from the accumulation of drift and the strong current, due to the rapid rising of the river. This rise continued, and finally culminated in a flood nearly as great as that of 1882, and thenceforth a very high stage of water prevailed continuously until about the end of July. During this period work was continued, though under very great disadvantages, and was of necessity mainly confined to work on the dikes, which required constant watching and repairs during this long-continued high water.

After the subsidence of the flood the construction of mattresses for bank revetment was resumed, but the season proved unusually sickly, and labor was scarce and inefficient. Nothing of consequence was accomplished until the advent of the cool weather in the fall, since which time work has progressed favorably and rapidly. Every endeavor has been made to place the work in as safe a condition as possible, but it is greatly to be feared that this can only be partially accomplished, as the funds now available, the balance of last year's appropriation, will only admit of carrying on active operations till about the middle of December, after which time all work must cease until Congress makes a further appropriation for its prosecution. The Commission feel that they cannot too strongly urge upon Congress the necessities of the case and the need of early relief, as the flood season with all its attendant danger is close at hand, and the Commission before that time will have exhausted all its available funds, only reserving such amounts as are absolutely needed for the care and preservation of the extensive and costly plant belonging to the works. An appropriation of $1,000,000 made immediately could be advantageously used.

The past year, with its many vicissitudes, has been fruitful in valuable experience, experience which was much needed, in view of the magnitude and of the untried difficulties of the work.

This experience has shown that the principles upon which the Commission have based their work are perfectly sound, and in this respect no modification seems necessary, though with regard to details of construction some changes have been called for.

The contraction works, consisting essentially of dikes of piling, sustaining curtains or screens of brush, proved generally too weak for the work imposed upon them. The great depth of water in which they must be maintained, the enormous accumulations of floating drift, and the long duration of the high-water period, are the main points in which our experience differs from any previously noted with similar structures at other localities. This has necessitated much more substantial work than was at first deemed necessary, with a proportionate increase of cost. It should, however, be noted with regard to these works, upon which the main damage experienced has been concentrated, that they are not necessarily permanent in their nature, and are only intended to effect certain definite results, viz, the silting up of certain portions of the river-bed. When this object has been accomplished their work is, as a rule, ended, and their maintenance will no longer be required. Meanwhile, from their position and the style of their construction, more or less damage at each recurring flood is inevitable and must be expected; but such damage should be made good as soon as possible, and the general continuity of the dikes preserved, in order to obtain promptly the desired results.

The revetment work undertaken, wherever completed, has proved entirely successful, and but slight modification in the general style and in details of construction has been found necessary. As the officers and men gain skill and confidence in this work, better results, both as regards rapidity of execution and economy in cost, may be expected.

Next to the scarcity of labor, the greatest difficulty met with has been the insuring of an ample and timely supply of the materials used in construction, especially brush and stone. Already the local supply of brush on the works is about exhausted, and it has to be sought either up or down the river at points 60 or 70 miles distant from the works. The bulk of the stone needed has to be brought from above Cairo, as the few local sources of supply are entirely inadequate to the demands of the work. This has created a demand for transportation which has taxed the resources of the Commission to the very utmost, and a considerable increase in the number of barges and tow-boats at their disposal must be made as soon as funds for the purpose are available. In other respects the plant on hand seems adequate for the work and generally efficient; though it is proper to state here that the plant provided for commencing work on the New Madrid Reach, and part of that procured for the Memphis Reach, has been absorbed by the works at Plum Point and Lake Providence.

With regard to the results due to the still far from completed works it would seem premature to speak; nevertheless these results have been so remarkable that they cannot be overlooked. During the months of September and October the river below Cairo was extremely low and navigation was carried on with great difficulty. Between Cairo and the Plum Point Reach there was but 5½ feet and 6 feet of water at several points; between that reach and Memphis and as far down as Commerce Cut-off, 40 miles below Memphis, 6 feet was found. From this point to the head of the Lake Providence Reach there was but 7 feet available, and between the Lake Providence Reach and Vicksburg but 9 feet. Below Vicksburg there were not less than 10½ feet.

During all previous low-water seasons, when similar depths have been reported, Plum Point and Lake Providence Reaches have been fully as shoal as any points on the river, and as a rule shoaler than anything in their immediate vicinity; yet during the present season there was not less than 12 feet depth through these two reaches, and at Lake Providence, during the lowest water, over 15 feet was reported. Thus these two long stretches of habitually difficult navigation showed this year a depth twice as great as the bars above and below them, and this result can only be attributed to the works executed by the Commission. That such truly remarkable effects should have been produced by the works in their unfinished condition is extremely encouraging as regards the ultimate success of the improvement.

As stated in their last report, the Commission have caused surveys to be made of the New Madrid, Memphis, Helena, and Choctaw Reaches, with a view to preparing detailed plans for their improvement when funds for the purpose become available. Allotments were made for New Madrid and Memphis Reaches, and a considerable amount of plant procured for beginning work thereon, but owing to the non-passage of the river and harbor bill it was decided to be inexpedient to undertake this work for the present, and such portion of the New Madrid allotment as had not been expended for plant was reallotted to Plum Point and Lake Providence. On the Memphis Reach work outside of the harbor proper was confined to the revetment of Hopefield Bend, a few miles above Memphis.

The surveys ordered at the mouth of Red River, and for a lock at Bayou Plaquemine, have not yet been completed, owing to the extremely unhealthy character of the season, which has rendered it almost impossible to keep a survey party in the field. For the same reason the survey ordered at Natchez Harbor has not yet been undertaken. At Memphis Harbor the work in progress at date of last report under a special allotment by the Commission has been completed, and the same is true of the revetment at Delta Point, Louisiana, opposite Vicksburg.

The allotment for dredging in Vicksburg Harbor was partially expended in that manner, though the work is now suspended for reasons set forth further on. At the mouth of Red River the same means for maintaining navigation were resorted to as in several previous years. They were attended by failure, as in 1881, and for similar reasons.

At New Orleans the construction of a mattress revetment in Carrollton Bend has been begun and is now in progress.

On all the portions of the river under improvement repeated surveys have been made to note any changes which might occur, and especially those due to the works constructed. At New Orleans, in addition, a series of discharge measurements, covering nearly a full year, have been made.

The details of administration, and the division of the river into four working districts, have remained throughout the year as described in our last annual report.

Full details as to expenditures will be found in the financial statements appended to this report.

WORKS BELOW CAIRO.

FIRST DISTRICT.

(Cairo to foot of Island No. 40, 220 miles in length. Officer in charge, Capt. J. G. D. Knight, Corps of Engineers, U. S. A.)

HEADQUARTERS, CAIRO, ILL.

In this district are included the New Madrid and Plum Point Reaches. The former extends from the head of Island No. 8, 42 miles below Cairo, to the foot of Island No. 14, a distance of 60 miles; and the latter from the head of Island No. 26, 147 miles below Cairo, to the head of Island No. 35, a distance of 40 miles.

NEW MADRID REACH.

A low-water survey of this reach was ordered in August, 1882, and was carried out during the fall and early winter. The maps of this survey have been completed, but no project for work has as yet been prepared. With the expectation of beginning work on this reach the Commission authorized the procuring of the following plant, viz: 20 pile-drivers, 40 barges, 1 machine shop, 6 quarter-boats, 4 200-feet mattress boats, 6 100-feet mattress boats, 6 screen boats, and 40 skiffs. Of this list, the pile-drivers, barges, and machine shop have been built and assigned to other works.

On December 19, 1882, it was decided to suspend such portion of the allotment as was not needed to pay for plant which could be utilized elsewhere, and on March 16, 1883, $300,000 of the allotment was transferred to Plum Point, and the balance, $187,500, to Lake Providence.

This action of the Commission was rendered necessary by the failure of the river and harbor bill, as it was deemed far more important to push the works already begun at Plum Point and Lake Providence as far along as possible than to attempt, with inadequate means, to initiate the improvement of another reach. Nevertheless, in the interest of navigation, this improvement should be undertaken at as early a date as practicable, as the bars on the reach were, during the recent low water, the shoalest and most troublesome on the river.

PLUM POINT REACH.

The work so far decided on for this reach comprises a system of longitudinal and cross dikes designed to close the chutes behind Elmot Bar and Island No. 30, a similar system for closing the chutes behind Osceola and Bullerton Tow-heads, and a third system designed to contract the water-way between Bullerton Tow-head and Yankee Bar, together with bank revetment on the left bank from Ashport to Gold Dust, on the right bank from Fletcher's to Elmot's, and from Petty's to Craighead Point, and along the outside of Osceola and Bullerton Tow-heads. Of this work at the date of the last report there had been constructed 2,700 feet of revetment near Ashport, and the head of Bullerton Tow-head had also been protected. The longitudinal dike of the Elmot or Gold Dust system had been built in part, as also a dike across the middle chute through Osceola Bar. The dike across the head of Osceola Chute was completed, and the one connecting Osceola and Bullerton Tow-heads was partly built. Subsequently five cross-dikes were commenced in Elmot Chute, and partly completed. Mattresses were constructed along the outside of Bullerton and Osceola Tow-heads, and wide foot-mats along the outside of the various dikes. Nearly all this mettress work was afloat when the river began rising in February, 1883, owing to the failure in the stone supply before alluded to. Attempts were made to sink the mattresses with bags of sand, but without success. The river rose very rapidly, and brought down immense quantities of drift, which accumulated under and against the floating mattresses, and finally tore them from their fastenings. In this manner a large amount of the mettress work which had been constructed was lost, and all attempts to renew it during the high water proved ineffectual. In similar manner the drift accumulated against the pile dikes. The foot-mats were either carried away or doubled up and destroyed, and the pressure of the masses of drift, aided no doubt by scour around the piles, overturned a large portion of the dikes which had been constructed. These breaks in the dikes relieved considerably the pressure against the remaining portions, and the greatest damage was confined to the first few weeks of the flood. Subsequently these dikes were in great part reconstructed in a much more substantial manner. Four cross-dikes were ordered in Osceola Chute, of which three have been constructed, and two in Bullerton Chute, the first of which only has been in part constructed, as the chute has been the channel during the low-water season. It is hoped that all these cross-dikes can be finished before the close of active operations.

The third system of dikes below Plum Point has been begun, and cross-dikes Nos. 1 and 2, with part of the main dike, have been built.

In all, there is now standing on this reach 37,815 feet of pile dike.

The revetment of the outside of Bullerton Tow-head has been completed during the present season, as also that of the head of Lower Osceola Tow-head. The revetment of the outside of this tow-head could not be renewed for want of funds. The revetment of Ashport has not been extended for the same reason. It has remained intact during the year. In spite of the damage which they sustained, the dikes did good service, and a general and extensive fill was noticed behind them. Had they been held intact their effect would undoubtedly have been much greater.

The crossing from Plum Point to Bullerton was moved down stream a considerable distance, but the failure of the Bullerton Dikes enabled the river at low water to cut through into that chute and maintain a channel there. It is, however, hoped and expected that the next high water will break down the bar outside and establish a channel to the left of the tow-head, where it is desired to locate it.

The effect of the partial concentration of the water on those portions of the reach under improvement was very marked during the late low-water season. The depth of water was not less than 12 feet, double the amount found on the unimproved portions of the river above and below.

For details of work in this district see report of Capt. J. G. D. Knight, Corps of Engineers, Appendix J.

SECOND DISTRICT.

(Foot of Island No. 40 to mouth of White River, 180 miles in length. Officer in charge, Maj. A. M. Miller, Corps of Engineers, U. S. A.)

HEADQUARTERS, MEMPHIS, TENN.

In this district are included the Memphis and Helena Reaches, the first extending from the foot of Island No. 40, 220 miles from Cairo, to Scanlan's Landing, a distance of 27 miles, and the second extending from Commerce Cut-off, 270 miles from Cairo, to Friar's Point, a distance of 55 miles.

The first reach includes Memphis Harbor.

MEMPHIS HARBOR.

This work, which has been in progress several years under the Engineer Department, United States Army, was carried on last year under the supervision of the Commission and by special allotment from the general appropriation.

The protection of the caving bank by mattress revetment from the freight elevator to Wolf River was completed in February, 1883. In all, since our last report, 5 mattresses covering 300 linear feet of bank have been constructed and sunk, and the upper bank has been graded and covered with stone throughout the whole distance, with the exception of two gaps, aggregating 450 feet. This revetment passed through the great flood of 1883 without any damage and is reported in perfect order.

MEMPHIS REACH.

A low-water survey of this reach has been completed, but no project for its improvement has as yet been prepared.

It had been the intention of the Commission to begin work on this reach, and a considerable amount of plant was ordered for the purpose; but owing to the failure of the appropriation, work was confined during the year to the construction of a mattress revetment in Hopefield Bend, where the right bank was rapidly caving and threatening the harbor of Memphis. This work was begun in December, 1882, and carried on till February, 1883, when it was stopped by the rapidly rising river, 1,127 feet of mattress revetment having been to that time constructed and sunk. Work could not be resumed till August, 1883, and is still in progress. To date 14,485 feet of bank have been protected, the under-water mattress being 140 feet wide. That portion which was first put in has stood perfectly well, although the water was five feet deep on top of the bank during the flood of 1883. It will be necessary to carry this revetment down to Hopefield Point, and also to revet about ½ mile of the left bank below the mouth of Frame Chute.

HELENA REACH.

A low-water survey of this reach has been made, but no project for its improvement has as yet been prepared.

For details of work in this district see report of Maj. A. M. Miller, United States Engineers, Appendix K.

THIRD DISTRICT.

(Mouth of White River to Warrenton, Miss., 220 miles in length. Officer in charge, Capt. W. L. Marshall, Corps of Engineers, U. S. A.)

HEADQUARTERS, VICKSBURG, MISS.

In this district are included the Choctaw Reach, extending from Cork's Point, Arkansas, 422 miles below Cairo, to Arkansas City, a distance of 31 miles; the Lake Providence Reach, extending from Carolina Landing, Mississippi, 530 miles below Cairo, to the foot of Island No. 95, a distance of 35 miles; and also the improvement of Vicksburg Harbor.

CHOCTAW REACH.

A low-water survey of this reach has been made, but no project for its improvement has as yet been prepared.

LAKE PROVIDENCE REACH.

At date of last report work on this reach was going on actively, and considerable progress had been made on the pile dikes closing the chutes behind Skipwith's and Duncansby Tow-heads, Island No. 93, Baleshed Bar, and Stack Island; and revetment was in progress along the face of Island No. 93. During the past season this work has been continued, the revetment of Louisiana Bend has been begun, as also the dikes closing Hopewell or Elton Chute.

In Louisiana Bend the work of revetting the bank has been commenced and to date about half a mile has been completed. This is a work offering peculiar difficulties, the water being over 100 feet deep at low water, while at high stages work is impossible, owing to the great depth of water and the extremely rapid current. This very important work was much delayed by the difficulty in procuring labor and must soon be stopped for lack of funds. The work completed will be in a very precarious condition during the next high water, as the caving during the last two years has aggregated 1,500 feet in width. The holding of this shore line is absolutely essential on account of its influence on the direction of the river below. The caving which took place last year caused considerable damage to the Duncansby system of dikes, as will be described farther on.

The Duncansby system of dikes is intended to exclude the river from the left-hand chute in front of Duncansby and Skipwith's Landings. The first series built comprised five cross-dikes, and a longitudinal dike extending to the lower tow-head in front of Skipwith's Landing. The longitudinal was a high dike; the cross-dikes were only carried to the 17-foot stage. The channel, when the work began, led into Skipwith's Chute, passing between the two tow-heads. This channel has been completely silted up, and the greater portion of the entire chute is dry at low water, but the caving in Louisiana Bend, above Pilcher's Point, during the last high water, threw the channel across the river, striking high up on the Mississippi shore, and the works at the head of the chute were severely attacked, and suffered considerable damage. As it was deemed desirable to hold this line as long as possible, in order to allow time for the chute to fill up and for the new channel to develop itself to the right of the tow-heads, three additional cross-dikes were built in the chute, and a screened dike above the head of the upper tow-head. Later on the head of the tow-head was revetted, but the water went entirely over it and cut a channel through behind the revetment. A heavy dike was also begun on range No. 36, and all the upper dikes of the system are being strengthened, so as, if possible, to keep the river out of the left-hand chute during the coming high water.

The Meyersville, or Island No. 93 system, includes a main dike and three cross-dikes on Cottonwood Bar, which are not yet built, a dike across the head of Island No. 93, built last year to the 17-foot stage, and a high cross-dike, to 30-foot stage, built across the chute at Meyersville Landing. These dikes have proved quite effective and the chute now goes dry at low water.

Previous to the rise in February, 1883, 1½ miles of low-water revetment had been constructed on the outside of Island No. 93, and the upper bank protection had been completed for 1,700 feet at the upper end; of this, the last 225 feet had not been properly ballasted for lack of stone and was carried away. All the revetment below this point was also lost for lack of protection of the upper bank. This work had therefore to be renewed this season and is now in progress.

At the foot of Island No. 93 begins the Baleshed system of dikes. It comprises a longitudinal dike extending from the Mississippi shore at Homochitto Landing to the head of Stack Island. Behind this longitudinal are twelve cross-dikes. Part of the longitudinal and four of the cross-dikes were built last year, but only to the 17-foot stage. Subsequent to February, 1883, and during the high water, work was carried on; all the cross-dikes were raised and strengthened, and eight others were built. All the new dikes extend to above the 25-foot stage, they are built with from 3 to 5 rows of piles and are wattled to a height of 6 feet above the present bar surface. Six of the cross-dikes are complete from the shore to the longitudinal, the six others have not yet been carried across the deep water. All the cross-dikes have foot mats, and the longitudinal has outside of it a 100-foot mat and a grillage mat and wattling wherever cross channels have been developed. The effect of these dikes has been very marked, a great fill having been secured behind them, with a corresponding deepening in the channel outside. In this system 28,000 feet of dike have been built during the year.

Much trouble was experienced at Stack Island where the river had established itself in the left-hand chute. This chute was over 80 feet deep at low water, and the Elton or Hopewell Chute on the other side of the river was over 30 feet deep. The new channel, as projected, crossed directly over Hopewell Bar. An open pile dike was built above the head of Stack Island to check the flow into that chute, and six short spurs from the right bank were thrown across the Elton or Hopewell Chute. When these works were completed the river broke through on the line desired, removing immense masses of sand and establishing itself in the position desired. These works must, however, doubtless be extended in order to keep it there.

The general result of the works has been a very marked increase of depth at low water. During the past season there was not less than 12 feet, and at the lowest water where the channel had cut out there was over 15 feet.

The systems of construction described last year have not been materially altered except in the direction of giving greater strength to the dikes, which, as now made, are much stronger, having from 3 to 5 rows of piles, and being all provided with foot mats. In 3-row dikes the middle row is wattled, in 5-row dykes the wattling is on the 2d and 4th rows. Wattling has replaced the curtains or inclined mats used last year, being found cheaper and more efficient.

In revetment work the hurdle mattresses described in our last report are still used, the only modification being the introduction alongside the poles of jointed iron rods of ⅜ or ⅝ inch iron for the purpose of increasing the longitudinal strength.

VICKSBURG HARBOR.

Prior to August, 1882, work at this locality had been for several years in progress under the Engineer Department, United States Army. Since that time it has been carried on under the supervision of the Commission, and has received an allotment from the general appropriation. Previous to this past season, work had been confined to the revetment of Delta Point, opposite Vicksburg, and the continuation of this work was in progress at the date of our last report. At that time 1,100 feet of the new work had been completed. Subsequently the work was continued with but slight modifications till February 10, when the allotment was exhausted. In all, 4,000 linear feet of substantial revetment was constructed, leaving about 500 feet to be built this winter. The cost of this revetment, which it is believed will be rarely, if ever, exceeded, was $13.37 per linear foot. It passed through the last flood without any damage, and seems to be in every respect satisfactory. The plan of improvement proposed for the harbor proper of Vicksburg contemplated the excavation of a basin in front of the town, connected by a canal with the deep water in the river. For this season it was proposed to excavate a basin 300 feet wide and 1,700 feet long in front of the elevator, and to connect it with deep water in the lake by a canal 150 feet wide, the west entrance to the lake being also kept open. All dredging was to be to the zero of the Vicksburg gauge. The contract for this dredging was let at 12.1 cents per cubic yard and, after many delays, work was finally begun on April 5, and continued till September 18, when the Commission decided to stop it. During this time, 350,035 cubic yards of mud were removed. The basin for a width of 160 feet was dredged to the zero of the gauge, and for a further width of 160 feet to the reference + 5 feet. The canal was excavated for a width of 80 feet to the zero plane, and an attempt was made to dredge the west entrance to the lake, which, since the project had been approved, had filled up to the extent of 17 feet. The material was hard sand and the dredging was so difficult that it was ordered to be abandoned on August 22. As the river fell, the sides of the dredged basin slid in and the bottom was pushed up by the weight of the soft mud lying beyond the dredged area. This upheaval amounted to about 8 feet in depth, and the basin was re-excavated for a width of 80 feet to the zero plane. Meanwhile, the continued fall of the river surface gave a considerable head to the water impounded in the lake, and it finally cut through the sand-bar at the west entrance, so that now boats drawing 5 feet are able to enter at a 12-foot stage, whereas before, at the 20-foot stage, all boats were excluded.

This effect, while very fortunate for the town, is in nowise permanent, as this cut will certainly fill up at the next high water, and may not cut out again so readily. A survey was made at low water, which showed that since May, or while the river was declining, a fill had taken place over the area covered by the proposed canal and basin amounting to from 5 to 20 feet in depth. Prior to May the fill had only been about one foot. On the line of the proposed canal alone the removal of 1,255,486 cubic yards more than originally estimated has already become necessary. It is needless to say that the Commission, in approving this plan, had not anticipated such a state of affairs as this. Repeated surveys, extending over the whole period since the formation of the cut-off, had shown that the fill, gradually diminishing in its yearly increment, had finally practically ceased as far as the inner harbor was concerned, and only on this condition could the plan have been recommended. When confronted by such an enormous fill, taking place, moreover, on the falling stage of the river, and requiring in consequence to be removed during the low-water stage, it became obviously necessary to call a halt until the matter could be further investigated. Such an annual fill as this will require $200,000 for its removal, and as it must be done during the low-water period, it would require a large fleet of dredges to accomplish it. Some changes have recently taken place at Young's Point, and above Delta, which have tended to throw the river nearer to Vicksburg. The eddy current up the east arm of the lake was observed to be greatly increased after June 1, and undoubtedly caused the great deposit. It is quite possible that this increased flow was due to the changes alluded to. If this, however, be the case, these changes may progress still further, and the annual fill may become even greater; in any case it would be extremely unwise to attempt any further prosecution of the plan for the present. The diversion of the Yazoo into the lake has been proposed with a view to keeping it open; but this is estimated to cost $1,600,000, and the excavation of the canal $766,000. The removal of the annual deposit will cost $200,000, or say $2,600,000 for the whole project, with no certainty as to the results. The annual commerce of Vicksburg is 10½ millions of dollars.

The following projects have been proposed:

1st. To abandon the lake and establish the town landing at Kleinston, holding Delta Point securely by extending the revetment. This latter must be done in any case.

2d. To dredge the west entrance annually, and to keep the basin clear. This would be temporary, and would cost at least $30,000 per annum after the first year.

3d. To divert the Yazoo into the west arm of the lake, dredging out the basin and connecting canal. This would cost $1,850,000, with annual dredging to an uncertain amount.

4th. To divert the Yazoo into the east arm of the lake and along the city front, dredging out the basin and canal to the river. This would cost $2,600,000 and would require annual dredging in the canal.

The first project involves the abandonment of the old harbor of Vicksburg, and is, naturally, extremely distasteful to the citizens of that place; the last two projects are expensive and by no means certain; while the second can at best be but temporary in its effects.

In the opinion of the Commission, further study of the whole subject is required before any final recommendation can be made; nevertheless, with a view to affording relief to the harbor during such time as will necessarily be required for this study, the Commission recommend that during the coming season an attempt be made to carry out the second project above described, should the conditions be found to be favorable.

For details of work in third district see report of Capt. W. L. Marshall, United States Engineers, Appendix L.

FOURTH DISTRICT.

(Warrenton, Miss., to Head of Passes, 484 miles in length. Officer in charge, Maj. Amos Stickney, Corps of Engineers, U. S. A.)

HEADQUARTERS NEW ORLEANS, LA.

This district embraces the improvement of Natchez Harbor, the rectification of Red and Atchafalaya rivers, a lock at Bayou Plaquemine, and the improvement of New Orleans Harbor.

NATCHEZ HARBOR.

A survey with a view to improvement was ordered at this place, but owing to the sickly season it has been found impossible as yet to make it. The caving of the bank in Giles' Bend has not been very great, but that in Marengo Bend has been more severe. The work required is bank revetment, and can be estimated on this winter.

RED AND ATCHAFALAYA RIVERS.

During the past low water, it again became necessary to send dredge boats to Old River to attempt to keep open navigation into the Red River. Although they reached the scene of operations while there was still a through channel depth of not less than 5 feet, the effort failed utterly, and, for a period of three or four weeks, navigation was entirely suspended. In fact, for a part of this time, the water-way entirely disappeared.

The experience of this year leaves no doubt of the absolute uncertainty of any such method of preserving navigation, during low water, into Red River. While in many years it may succeed, it is utterly inefficient in the face of the unfavorable conditions that may recur any season. The dredging fleet cannot operate until the water has fallen to a certain stage. After this stage is reached, it is entirely probable that the fall may continue so rapidly as to develop the bars much faster than the dredges can remove them. The difficulty of maintaining a channel upwards of four miles long, of navigable depth and width, in a sedimentary river, falling several inches a day, with a current unable to scour from its own debility, and the unctuous and adhesive quality of the bed material, would seem to be sufficient. But it is much increased in unfavorable years by the falling of the water more rapidly than the banks can dry out and solidify, or than the overflow ponds a short distance back can drain. On such occasions the semi-fluid banks slough down in immense masses, at times entirely choking the water-way.

These difficulties may recur any year, and render uncertain any attempt to keep open Red River navigation by such methods, during low water.

Still, as no better temporary method is known, and as this method has succeeded in a majority of the years in which it has been tried, and as the commercial benefits of maintaining water communication with a large producing region during the months when it is most needed for shipments are very great, exceeding the cost of dredging operations, it is recommended that, until permanent improvement of this navigation be accomplished, sufficient appropriation (as provided for in the accompanying estimates) be made to renew the work of dredging at this point when it may again become necessary.

Surveys and examinations at this locality have been prosecuted under almost equal difficulties. Immediately on the subsidence of the last flood parties were put into the field to secure information necessary for the preparation of a plan for the permanent improvement of the junction of these three rivers; but, owing to the natural difficulties of the ground and the unhealthfulness of this region, their labors are still incomplete.

Fuller details and discussions of these topics will be found in the report of Maj. A. Stickney, United States Engineers, district officer, submitted as Appendix M.

The following brief description of the existing regimen, and of the conditions which must be harmonized in any permanent plan of improvement, as observed during the past two floods, is submitted. The sectional area of Lower Old River has contracted considerably, while the enlargement of the Atchafalaya has continued. These changes are clearly the effect of the floods.

The fill in Old River is the result of the absence of current during the equilibrium held between that portion of the flood coming down the Mississippi and the overflow through the Tensas Basin, re-enforced by Red River. The scour in the Atchafalaya, considered in connection with the fill in Old River, proves that the volume causing it is not drawn directly from the Mississippi, but rather from the overflow in the Tensas Basin. The shape of the sand reefs left by the flood current substantiates this. A dam across Lower Old River, therefore, would not change the existing tendencies of the floods. The equilibrium of the accumulated mass of flood water in this region is first disturbed by a decline in the Mississippi, which starts the current in that direction. But so immense is this volume of overflow that the fall is checked by it when near a bank full stage. In 1882 it lingered fifty-one days between the 42 and 41 foot marks on the gauge at Red River Landing. When once within the banks, the decline is more rapid. The fall of the Atchafalaya is still slower than that of the Mississippi, as in addition to its share of the Tensas it has to collect and carry off its own overflow, which spreads from the Mississippi to the Têche.

The flow through Old River towards the Atchafalaya usually sets in after mid-stage on the decline is reached, and becomes more fixed as the water continues to fall. These observations are general, and a local rise in either the Mississippi or Red River may disturb or reverse the movement. A flow through the Old River to the Mississippi is, under present conditions, advantageous to the navigation of the former stream, as it has greater velocity and less sediment than a current in the opposite direction.

The exclusion of the overflow from the Tensas Basin, by the completion of its levee system to Blackhawk, would prevent the equilibrium between the Mississippi and overflow waters in and about Old River and the head of the Atchafalaya, which is noticed in floods, and would tend to increase, both in duration and amount, the flow from the Mississippi down the Atchafalaya by way of Lower Old River. This change would probably not only prevent the further filling of Lower Old River, but would enlarge it, and ultimately accelerate the enlargement of the Atchafalaya. The prevention of the escape of flood waters, complete or partial, down the Atchafalaya would have, as an immediate effect, the greater or less increase of flood height in Old River, and steeper slope from its mouth down the Mississippi. This would precede the ultimate adjustments of the bed to the increased volume. This subject is further discussed under the head of levees and outlets.

The Commission is as mindful of the importance of this part of their work as of its difficulties. Upon the completion of surveys and examinations now in progress, full report and recommendations will be made.

LOCK AT BAYOU PLAQUEMINE.

The surveys for this work are not yet completed, having been delayed by the unhealthiness of the past season.

NEW ORLEANS HARBOR.

The project for laying 10,000 feet of mattress revetment 400 feet wide in Carrollton Bend was approved September 18, 1882. Work was begun October 9, 1883, but has made little progress to date, owing to trouble in securing a supply of brush.

In the third district the plan of scouring out the mud from under the wharves by the use of a tug has been tried with success.

On the right bank from Westwego to Algiers there has been serious caving, involving much loss to property of considerable present and much greater prospective value. Fully 40,000 feet of bank will require protection.

An interesting series of discharge observations were obtained at Carrollton between January 27 and September 7, 1883. The discharge was measured 148 times, and the observations extended from a 2-foot to a 15½-foot stage.

For details of work in this district see report of Maj. Amos Stickney, United States Engineers, Appendix M.

PLANT AND GENERAL SERVICE.

There was in use on the work during the past season the following plant, in part owned by the Government and in part chartered:

Owned by the Government.—One hundred and eighty-nine barges, thirty-nine quarter-boats, four screen-boats, three machine-shop boats, five steam tow-boats, one pumping-boat, twenty-five mattress boats, four hydraulic graders, one steam-tug, and sixty-two pile-drivers.

Chartered.—Six steamers and six barges.

The general service of supply and towage, as well as the construction of plant, was throughout the year in charge of Capt. C. B. Sears, Corps of Engineers, United States Army, the executive officer of the Commission in the department of construction, to whose report reference can be made for details. (See Appendix H.)

Estimates.

At a meeting held June 26, 1883, an estimate was made for the continuance of work then in progress, and this estimate was duly forwarded to Congress through the honorable the Secretary of War. At that time the Commission did not deem it best to make any recommendation or estimate in reference to new works of improvement, the works then in progress being in a comparatively incomplete state, and their results as yet undeveloped. Since that time the progress of the works and the favorable results produced by them have been such as to warrant the belief that work can be undertaken in one or more additional places, if it shall be the will of Congress to carry it on simultaneously in more places than those at which it is now in progress.

In this case the Commission would recommend that the improvement of New Madrid Reach be first undertaken; and secondly, that of Memphis Reach.

Estimates for this work are submitted herewith, and the estimate previously sent in is repeated.

LEVEES AND OUTLETS.

Work, under the allotment made by the Commission, from the appropriation of August 2, 1882, has been continued during the year on those levees which were not finished before the flood of 1883. It is expected that all will be completed before the expiration of this year. More detailed notice of this work will be found in the reports of the district officers.

The Commission now recommends the continuation of levee work during the next season on the fronts of the Tensas and Yazoo Basins.

Surveys and examinations, to ascertain the condition, cost, and effect of levees, have been continued during the past year. The limit of topography of the surveys extends back from the river, to include the site and height of all existing levees.

Besides this, special examinations of two distinct characters have been undertaken and carried far enough to yield important information.

1st. To ascertain the effect of outlets, particularly in the form of crevasses, resurveys have been made in the neighborhood of several of the great breaks of 1882, to compare with the general survey which was extended over the river in the years 1880 and 1881. The result of this work is graphically shown and accompanied by descriptive text in Appendix D.

In every observed case large loss of section occurred as follows:

Place.	Contraction.	Contraction.
	Square feet.	*Percentage.*
Malone's	2,200	.04
Riverton	11,000	.14
Bolivar	8,400	.11
Mound Place	23,800	.24

The above figures are the means of numerous lines run at each place. It is worthy of notice that the later of these comparative surveys were taken at lower stages of water than the earlier, and therefore, through the bars, other things being equal, a more deeply excavated bed might be expected in the later surveys. But, as the contrary is the case, it may be inferred that the observed net results are decreased rather than exaggerated by the relative conditions prevailing at the time of survey. Similar observations have been made during the year at Bonnet Carré crevasse, with this difference: the foregoing comparisons were between channels before and after the breaking of the crevasses, while the following is between a channel during the flow of a crevasse and after its closure. The results harmonize. Through this part of the river (35 miles above New Orleans) such depths prevail at all stages that great changes may occur without affecting navigation; but valuable opportunity for observation on crevasse effects was afforded, at a point where conflicting statements had been made with equal vehemence. Careful surveys were therefore made while the crevasse remained open, and repeated over the same lines, in the fall of 1883, after the crevasse was closed and the flood of that year had passed. The final results of this work are not yet prepared, but the change observed is scour throughout the reach below the crevasse, amounting to approximately 12 per cent. of the low-water area.

In the last report of the Commission (Appendix F, p. 116) will be found the results of gauging observations on the Mississippi, at and above Saint Louis, in the years 1880 and 1881. Similar observations were undertaken in the fall of 1881, at Paducah, on the Ohio, and at Columbus, Helena, Hay's Landing, and Red River Landing, on the Mississippi below Cairo, and continued into the fall of 1882. The value of this series was much enhanced by the fortunate occurrence in this year of the greatest recorded flood. Accompanying this report, as Appendix F, will be found the tabulation and plotting of their results. They have not been long enough available to have received complete investigation. Certain facts, however, are quite apparent in both series. It is observable that the rate of velocity and discharge, during a rise, increases more rapidly while the river is still within its banks than during the higher stages when the banks are submerged, or escape occurs through outlets. At several of the stations the increase of velocity is entirely arrested at about a bank-full stage, and, before that elevation is reached, absolutely greater velocities, and even discharges, were found than at higher stages, when much of the volume was lost over the banks. This phenomenon probably continues while the swamps are filling, and the draft from the river is across the banks. After they are filled to or near the height of the river, this indirect motion, and its loss of power, ceases, or becomes a very gentle one, generally parallel with the river, forming what may be termed a "water bank." It is fairly inferable from this, that if the conditions under which a certain curve, representing the increment of velocity and discharge, while the river is still within its banks, was developed, were continued, the form of the curve, throughout its upward extension, would be maintained, and that the additional height required for levees to restrain maximum floods would be less than that computed alone from a consideration of the increase of volume.

An illustration of the accuracy of this inference, as well as of the way in which flood heights are immediately augmented within the river bed, under existing physical conditions by crevasse outlets, is found in the comparative conduct of the high waters of 1882 and 1883, along the front of the Yazoo Basin. Although the volume discharged by the flood of 1882 was unquestionably greater than that of the subsequent year, owing to its duration, yet, from Cairo to Helena the waves attained heights nearly equal to each other, and, in both cases, above those of previous records. The same conditions, as regards outlets, or the gaps in the Saint Francis levees, prevailed during the two years. At Helena, in both floods, the maximum heights were reached on the return of the overflow from the Saint Francis Basin. But the first of the two floods under consideration wrought great havoc on the levees at the head of and along the upper part of the front of the Yazoo Basin. Of 1,500,000 cubic feet per second gauged at Helena at the top of the flood, one-third, or 500,000 cubic feet, were estimated by the assistants of the Commission charged with that duty, as escaping from the river through these breaks.

Notwithstanding this depletion, which left in the river bed a volume not exceeding that which the Helena and Hay's Landing gaugings indicate can be discharged at these stations at a stage, respectively, 6 and 5 feet lower than the maximum readings of the year, or, approximately, at a bank-full stage, the greatest flood heights were reached along the entire front of the basin.

The most destructive work of this phenomenal flood was, however, near the lower end. The water leaving the river through the crevasses at the head, and along the front, sought the lower levels near the mouth of the basin. The Yazoo River and other branches of the natural drainage system were inadequate to afford it exit. It accumulated in the basin to a height of several feet above the level in the river, until, overtopping the levees, an equalization of height was established between the river and basin, above the mark that would have been reached by the flood passing through a proper channel.

In 1883, the flood wave reached Helena with approximately the same height as in the previous year, but overflow into the Yazoo Basin was prevented by the holding of the levees which had broken the year before. In passing along the Yazoo bottom, the wave did not vary materially, in height, from that of 1882, until the lower end was reached. Here, owing to the exclusion of overflow from the head of the basin, but little return flow to the river, beyond the natural drainage, occurred, and the height of 1882 at Vicksburg, the nearest gauge, was not reached by about five feet.

While these two floods attained, approximately, the same heights along the part of the river under discussion, the difference in velocity was very marked. Gaugings in 1882, when the overflow into the Yazoo Basin was enormous, established the sluggish movement of the water during high stages. This was also the personal observation of all classes engaged on the river; engineers, steamboatmen, and planters. In 1883, when the flood wave was excluded from the Yazoo bottom, the great velocity along its front was universally noticed by the same observers.

The conclusions to which these facts contribute evidence may be thus stated. The loss of volume through high-water outlets causes both a diminution of velocity and a deflection of the thread of movement of the stream towards the outlet, accompanied by loss of the power necessary to transport the material with which it is loaded. The excess of load is dropped in the bed, decreasing the section below the outlet. When these conditions recur frequently, and are extended over long parts of the river, as the front of any one of the great basins, where volume is alternately reduced and augmented, the injury inflicted on the river as a channel or as a drain is cumulative, leading to general deterioration.

If the change from low water to flood, with its enormous range in the measure and direction of the river's forces, is unfavorable to the development of a navigable and permanent channel, or an effective discharge section from the different conditions, in the same place, at different times, it certainly increases these difficulties to allow the introduction of different conditions, at the same time, in different places.

The relief from excessive flood heights which might have been anticipated from the decrease of discharge below the outlet is not realized, owing to the immediate diminution of velocity, and of *vis viva*, and the consequent contraction of sectional area. Besides, the flood-water which escapes through the outlets is returned to the river at a point lower down under conditions which give it a power of increasing the flood's height to an elevation which would not have been reached by the same volume passing down the legitimate channel.

The facts observed during the past year, of which the more important have been here recapitulated, have corroborated the views of the Commission heretofore expressed in reference to the utility of levees as a means of channel improvement. This statement is made, as heretofore, with the limitation that for purposes of channel improvement merely, the limit of economy is reached with the confinement of the ordinary flood, and does not extend to the restraint of the abnormal or extraordinary flood. The result of this qualification is that the building of levees to the height necessary to protect the alluvial basin from overflow is not necessary as part of a logical plan of river improvement. The work of determining approximately what will be the necessary height of such system of levees has been in the hands of a committee since a time prior to the last report, who will report upon it as soon as the extensive investigations necessary to reach satisfactory conclusions upon the subject can be finished.

In the mean time it is proposed to complete the closure of gaps in the existing levees along the Yazoo and Tensas fronts begun a year ago, as the most economical and the shortest method of shutting off the escape of water into those great reservoirs and securing so far the benefit of the entire volume of the river's ordinary discharge in the improvement of the channel. Beyond that the Commission is not prepared at this time to make any specific recommendation for construction of levees as a means of channel improvement, and reserves the subject for further consideration.

The act creating the Commission makes it the duty of the Commission to consider the subject of the prevention of destructive floods, and, as bearing upon that matter, there is submitted for information the following summary of the probable extent and cost of such system of levees as would be necessary for that purpose.

It may be stated, further, that there are serious practical difficulties in the way of constructing a system of levees no higher than would be necessary for the confinement of ordinary floods, and at the same time protecting them against disastrous injury from the great floods which occur at irregular intervals. The practicability and probable cost of such protection is one of the subjects in the hands of the committee before referred to. It is obvious that for the secure protection of the valley from overflow there is necessary a system of levees high and strong enough to withstand the greatest flood. No other means of protection is practicable or even possible. These facts suggest obviously the idea of co-operation between the General Government and the communities interested in the prevention of overflow in the maintenance of a levee system which shall serve at the same time the purpose of improvement in the channel and protection from overflow. And, as preliminary to the consideration of such a suggestion, the probable cost of such a system is material.

2d. The other special investigation undertaken during the past year and alluded to above had for its object an estimate of the amount of levee work required to close existing gaps and give such grades as are shown in the following table. It is believed that a grave misapprehension prevails concerning the quantity and cost involved therein.

While the figures submitted in the following table are not final, they are of sufficient authority to be used in correcting misleading statements and in comparing the benefits with the cost of levees.

Two facts should be borne in mind:

First. For about half the distance below Cairo only one side of the river requires levees. For the remainder of this side the hills are so near, at distances ranging from immediate contact to not over six or eight miles, that the loss of volume of discharge over the intervening strips of bottom land is not considered of grave importance.

Second. By far the greater part of the required work is now in existence, having been constructed by the riparian communities and owners for the purpose of land reclamation.

Estimate of cubic yards of earthwork required for levees on the Mississippi River at certain grades.

No.	Location.	Length.	Grade.	Contents.	Remarks.
		Miles.		*Cubic yards.*	
1	Commerce, Mo., to Cairo.	85	2 feet above high water, 1882.	1,908,000	No survey has been made here. The estimate is prorated per mile of length from line run from Cairo to Island No. 40. It is believed to be ample, as the banks are not so low as those below, and the overflow is from backwater having little slope.
	Cairo to Island No. 40.	220	....do	11,989,000	This estimate is based on special survey. Grade of survey 1 foot above high water, 1882. Increase made by adding one foot to height, with proportionate section. to mean sectional area over entire distance.
3	Island No. 40 to mouth of Saint Francis River.	75	....do	2,098,000	This estimate is made from surveys and computations made for the purpose (see Appendix K 5) with grade of 1.5 feet above high water, 1882. The quantities for the additional 0.5 foot is added as above.
4	Helena to mouth of White River.	80	....do	1,000,000	The swamp basin (White River) back of this line is of small capacity compared with the Saint Francis, Yazoo, and Tensas. The line has been well maintained up to 1882. The above amount is believed to be sufficient for necessary repairs.
5	Arkansas City to Louisiana line.	90	3 feet above high water, 1882.	2,903,000	This estimate is based on a special survey for alternate grades at high water, 1882, and 1.5 feet above this mark. The difference between those two is 338,856 cubic yards. The average height of the levees on the opposite side of the river below Greenville is 6.06. Assuming the same mean height on this side, this amount is for raising from 6.06 to 7.56. The proportion carried out would make the further raising from 7.56 to 9.06, or 3 feet above high water, 1882, require about 424,000 cubic yards, giving the accompanying total.

Estimate of cubic yards of earthwork required for levees on Mississippi River, &c.—Cont'd.

No.	Location.	Length.	Grade.	Contents.	Remarks.
		Miles.		*Cubic yards.*	
6	Louisiana line to opposite Warrenton.	100		8,426,080	This is the estimate of the assistant engineer in charge of the line for raising the levees 3 feet for their entire length. As the grade of the line is very uneven, this quantity of earthwork, applied to the lowest places, would raise the grade of the line more than 3 feet. It is believed to be sufficient for a safe grade. (See Appendix —.)
7	Opposite Warrenton to Red River.	150		5,140,000	No survey has been made of this line, but the same provision is made in the estimate as in that from the Louisiana line to opposite Warrenton, viz, a uniform addition of 3 feet over the entire line, on an assumed height of 6.06 feet.
8	Red River to forts below New Orleans.	279	2 feet above high water, 1882.	6,652,000	This line is now complete in length, but of insufficient grade. The necessity for higher grade is explained in the following text. The assumed mean height is 7 feet, to be raised to 9 feet. In the execution of the work much the greater part of the addition would, of course, be made to the upper part of the line.
9	Horn Lake to Friar's Point.	70	....do	1,276,000	This estimate is based on surveys and computations made for the purpose (see Appendix —). An addition of half a foot is made to the original, making the grade of this estimate 2 feet above high water, 1882.
10	Friar's Point to Sunflower.	34	....do	620,000	There exist but two breaks in this line, but the estimate is prorated per mile from the foregoing line.
11	Sunflower to mouth of Yazoo River.	220	3 feet above high water, 1882.	8,925,000	This estimate is based on the report of the United States assistant engineer and engineer of Mississippi levee district (see Appendix —). The same remark applied to estimate from Louisiana line to Warenton is true here.
12	Baton Rouge to forts below New Orleans.	200	2 feet above high water, 1882.	4,838,000	The remarks applied to line from Red River to Forts is repeated here. The conditions are precisely the same.
				45,775,080	
	Cost at 25 cents per cubic yard.			$11,448,770	

The Commission is not prepared to state that these are the exact grades that are likely to be adopted, but it is not believed that grades in excess of these, on the average, will be required for the purposes set forth in the organic act, unless a change of regimen occurs from some remote cause, such as the extensive clearing of the precipitous sides of some of the tributary basins.

It has been the experience of the General Government, as well as of the riparian States, that such embankments as the above can be constructed for an average price not exceeding 25 cents per cubic yard, giving a result of $11,443,770.

In conclusion of this subject, the Commission considers it necessary to call the attention of Congress to peculiar conditions existing below Red River. This section of the river is in a state of much greater stability than is found in any other part of its course below the junction of the Missouri. At a short distance below Red River it becomes narrower and deeper. It has been leveed throughout for a great many years. No flood complications arise here, as above, from the return of overflow water which has escaped from the river at points higher up. This all reaches the sea through the numerous delta bayous on either side. Its bed, enlarged by levees, is fairly adapted to the drainage service which has hitherto been imposed upon it.

During the floods of 1874, 1882, and 1883 this part of the river was filled to its utmost capacity. The levees were a wash for hundreds of miles, and the waves of passing steamers rolled over them. Many disastrous breaks occurred.

The gaugings at Carrollton in 1883 showed that the river at this point was only discharging, at a maximum, about 1,100,000 cubic feet per second, while those at Red River Landing in the previous year showed that double this volume, or about 2,200,000 feet, found its way down the valleys of the Mississippi and Red rivers.

While it is not anticipated that the completion of the levees of the Tensas front to within 20 miles of Red River, and the confinement within the river of that part of the flood which has been allowed to escape above will cause greater flood heights at the mouth of Red River, it seems certain that it will have the effect of increasing and making constant the outlet of the Mississippi through Old River down the Atchafalaya.

Measures that may become necessary to prevent this, by diminishing the discharge of the Atchafalaya, or by directing more of the Red River flow down the Mississippi, will throw into the latter stream a volume in excess of any known discharge. While this increased volume would undoubtedly make room for itself by ultimate enlargement of section, it could only do so by the work of scour, the resistance to which would be indicated and measured by increased slope, or greater elevation of surface throughout that part of the river while undergoing enlargement.

Such additional service should not be imposed upon a region in which have been adopted the measures necessary, under existing conditions, for protection from inundation, without due preparation for the increased height which will be given the floods.

LEGISLATION.

The Commission repeats with emphasis the recommendation made in three preceding reports, that provision be made by law for the appropriation, by suitable proceedings, of land and material necessary in any work of Mississippi River improvement undertaken by the Government. Within the past year some serious inconvenience has been suffered from exorbitant demands made by land-owners for brush and piles. These materials are, in most cases, worth little or nothing to the owner, and are unsalable to any buyer except the Government at any price. But at the prices some owners ask for them they would make a large item of cost. It is not believed that there would be frequent occasions to resort to condemnation of private property, if such proceedings were authorized, as in most cases the existence of the power would be a sufficient preventive of extortion; although cases may arise in which the possession and exercise of the power would be highly important.

It is highly desirable, also, that Congress shall prescribe by law the extent to which material found on islands and bars in the river may be used without payment of damages. It is believed that the supreme right of control and improvement of rivers navigable for inter-state commerce which is vested in the United States carries with it the right to use in the work of improvement, without the consent of any individual owner, all such material as may found within the limits of the river itself, and constituting part of it. Upon this point differences of opinion are liable to arise between the engineers in charge and riparian proprietors, to avoid which there should be such express provision of law as will define the respective rights of the Government and the private owner as clearly as possible.

It is recommended also that provision be made by law for retaining control by the Government over areas of lands built up from deposits induced by the works of improvement placed in the river bed. These amount in some instances to hundreds of acres, and in some localities riparian owners may be disposed to claim possession of them to the detriment of the improvement. It is expected that in most such cases it will be found desirable to encourage the growth of trees upon the newly made banks, and occupy them in that way for many years, and perhaps permanently.

It is regarded as important, also, that a law shall be enacted for the punishment of any person who shall make a cut-off at any neck or bend in the Mississippi River. The history of the river indicates a tendency to recurring cycles of change. A cut-off is followed by a sudden increase of velocity in its vicinity, and by rapid caving above and below. These are likely to cause other cut-offs, one after another, and there then results a widely-extended and long-continued disturbance of the regimen of the river. During the continuance of such a period, works of improvement in the channel would be attended with the greatest difficulty. No great cut-off has occurred since that at Vicksburg in 1876, and the present conditions of the river in that respect are regarded as favorable. But the conditions are also existing for the introduction of a cycle of change by the making of a single cut-off, the injurious consequences of which it is impossible to estimate. Such events have happened in the past through the lawless acts of individuals, and against these, stringent penalties should be provided.

FINANCIAL STATEMENT.

Appropriation for surveys and expenses of the Mississippi River Commission, act of March 3, 1883.

Balance on hand December 16, 1882	$91,780 88
Appropriated by act approved March 3, 1883	150,000 00
Total	241,780 88
Expended from December 16, 1882, to November 30, 1883, including estimated liabilities	174,700 00
Balance which it is estimated will be required during remainder of fiscal year ending June 30, 1884	67,080 88
	241,780 88

The estimate of funds for fiscal year 1885, which was transmitted to the honorable the Secretary of War on June 25, 1883, is here repeated.

ESTIMATE OF FUNDS FOR SALARIES AND EXPENSES OF THE COMMISSION FOR NEXT FISCAL YEAR.

To continue the "surveys of the Mississippi River between the Head of the Passes, near its mouth, and its headwaters, now in progress"; to make "additional surveys and examinations of said river and its tributaries"; to make such additional examinations and investigations, topographical, hydrographical, and hydrometrical, as are necessary for maturing a plan for the permanent improvement of the entire river; for salaries and expenses of the Commission in traveling, mileage, and inspection, for office expenses, computing, draughting, &c., and for publication of maps and results	$200,000 00

The estimate of funds for works of improvement for the fiscal year 1885, which was transmitted to the honorable the Secretary of War on June 26, 1883, is here repeated.

ESTIMATE OF FUNDS FOR WORKS OF IMPROVEMENT FOR FISCAL YEAR ENDING JUNE 30, 1885.

For works of improvement on the Mississippi River below Cairo, including works in progress in the Lake Providence, Plum Point, and Memphis Reaches; the completion of the closing of existing crevasses and outlets on the Tensas and Yazoo fronts; the rectification of the Red and Atchafalaya Rivers, and the harbors of Memphis, Vicksburg, Natchez, and New Orleans	$3,000,000 00

In addition to the above, and as explained in the foregoing report, the Commission presents the following:

Supplemental estimate for the New Madrid and Memphis Reaches for fiscal year ending June 30, 1885.

For work on the New Madrid Reach	$1,000,000 00
For work on the Memphis Reach	675,000 00

FINANCIAL STATEMENTS.

Appropriation for improving Mississippi River, act of August 2, 1882.

Balance December 1, 1882	$2,388,000 00
Amount expended to November 1, 1883, including outstanding liabilities (estimated) to January 1, 1884, for steamboats, pile-drivers, and other floating plant; for materials, tools, supplies, and labor, continuing and beginning work at Plum Point, and Lake Providence, Memphis, and New Madrid; for subsisting and quartering the labor employed, and for payments on contracts for construction and repair of levees	2,187,730 80
Balance available and unpledged January 1, 1884, and which will be required for care of property and maintenance of organization during the remainder of the fiscal year	200,269 20
	2,388,000 00

Appropriation for New Orleans Harbor.

Balance on hand July 1, 1882	$147,793 81
Expended from July 1, 1882, to November 1, 1883	38,414 90
Balance available November 1, 1883	109,378 91
	147,793 81

Appropriation for improving mouth of Red River.

Balance on hand July 1, 1882	$90,812 40
Expended from July 1, 1882, to November 1, 1883	51,970 66
Balance available November 1, 1883	38,841 74
	90,812 40

Appropriation for Natchez Harbor.

Balance on hand July 1, 1882	$8,252 04
Expended from July 1, 1882, to November 1, 1883	2,920 62
Balance available November 1, 1883	5,331 42
	8,252 04

Résumé.

Total amounts of funds in Treasury and in hands of disbursing officers, November 1, 1883:	
Appropriation for improving Mississippi River	$844,717 13
Appropriation for New Orleans Harbor	109,378 91
Appropriation for mouth of Red River	38,841 74
Appropriation for Natchez Harbor	5,331 42
Total	998,269 20
Estimated liabilities to January 1, 1884, including retained percentages and balances due on contracts for levee work and outstanding liabilities for material and labor on works of construction	798,000 00
Balance available, as above	200,269 20

CHAS. R. SUTER,
Major of Engineers, U. S. A.
HENRY MITCHELL,
Coast and Geodetic Survey.
B. M. HARROD.
ROBERT S. TAYLOR.
S. W. FERGUSON.

I concur in the foregoing report, except so much of it as relates to levees and outlets, on which subject I will submit my views separately.

C. B. COMSTOCK,
Lieutenant-Colonel of Engineers, and Brevet Brigadier-General,
President Mississippi River Commission.

I concur in the foregoing report of the Commission, with the single qualification that the value of levees as a factor in the problem of channel improvement in preventing the wide dispersion of flood waters, is not affirmed in the report in sufficiently positive terms, and with that clearness and prominence to which, in my judgment, it is entitled.

Q. A. GILLMORE,
Colonel of Engineers, Brevet Major-General, U. S. A.

As I am unable to concur in the part of the report relating to levees, I submit the following remarks:

The Commission state—

> The act creating the Commission makes it the duty of the Commission to consider the subject of the prevention of destructive floods, and, as bearing upon that matter, there is submitted for information the following summary of the probable extent and cost of such a system.

The Commission submits an estimate for levees, to prevent destructive floods, from Commerce, Mo., to the forts below New Orleans, and proposes heights for them of two or three feet above the high water of 1882. The cost of the proposed system is estimated at $11,443,770, and, for the reasons stated hereafter, is, in my judgment, too small for any adequate system of levees intended to prevent destructive floods and (except at intervals of 15 or 20 years) to secure the property of the inhabitants behind them from danger of destruction.

Before a system of levees can be planned the question must be decided whether it shall be attempted to confine the greatest floods, or only those somewhat less than the greatest. When it is remembered that the cost of these levees will necessarily be great; that, as they will be high, breaks through them will involve large costs in repairs; that their object is to make possible the safe existence behind them of a large and productive population in the alluvial bottoms they protect; that only the expectation of such a population can justify the large expense involved; that breaks in the levees, when the bottoms are filled up by plantations, would involve enormous loss of property; that the annual height of floods in rivers is now believed to increase as the country they drain is cleared up; in view of all these considerations it seems the wiser plan to face at once a great flood, and to provide for its confinement between levees.

It may be said that with interest at 3 per cent. it would be cheaper to allow great floods once in ten or fifteen years to overtop and largely damage the levees than to incur a greater expense to avoid an evil that occurs only at such intervals of time. But, as has already been said, the only economical justification of the expense involved in an efficient system of levees is the belief that in time the whole region protected from overflow shall become populated and highly productive. When that time approaches the damage done to levees by floods which went over them would be insignificant in proportion to the incalculably greater damage done to the population behind them.

Moreover, great floods are not rare.

At Cairo, between 1862 and 1883, inclusive, four floods have reached or exceeded a reading on the guage of 50.8 feet; the highest known reading being 52.4 feet, in 1883. A flood of 51.5 feet may then be looked for once in ten years.

At Memphis, between 1858 and 1883, inclusive, the gauge reading has equaled or exceeded 34.0 feet six times; the highest reading being 35.1 feet, in 1882. A flood of 34.5 feet may be expected once in ten years.

At Helena, between 1867 and 1883, inclusive, floods have four times equaled or exceeded a gauge-reading of 45.8 feet; the maximum being 47.2 feet, in 1882. A flood of 46.5 feet may be expected once in ten years.

At the mouth of White River, between 1862 and 1883, inclusive, the floods have five times given a gauge-reading of 46.6 feet. or more; the highest being 48.5 feet, in 1882. A flood of 47.5 feet may be expected once in ten years.

At Vicksburg, between 1858 and 1883, inclusive, floods have four times given gauge-readings of 48.8 feet or more; the highest being 51.1 feet, in 1862. In 1882 the flood only reached 48.8 feet, the maximum since 1867, and may have had its height diminished by the Vicksburg cut-off of 1876. A flood of 49.0 feet may be expected once in ten years.

At Natchez, between 1858 and 1883, floods reached a gauge-reading of 47.9 feet or more five times; the maximum being 50.3 feet, in 1862. A flood of 48.0 feet may be expected once in ten years.

At Red River Landing, between 1867 and 1883, the gauge has in three years had a flood reading of 46.3 feet or more, the maximum being 48.6 feet in 1882. A flood of 47.0 feet may be expected once in ten years.

At Carrollton, floods have reached a gauge-reading of 15.4 feet, or more, five times between 1859 and 1883, the highest being 15.9 feet in 1862. A flood of 15.6 feet may be expected once in ten years.

These statements refer to the river as it has been since 1858.

In the preceding statements of floods that may be expected once in ten years, the heights are adopted from an examination of the heights of the floods mentioned.

The following table recapitulates the preceding information, and gives also the lowest readings on the gauges, with their years, and the high-water readings in 1882:

Distance in miles from Cairo.	Stations.	Highest high water.	Year.	Lowest low water.	Year.	Gauge-readings for flood to be expected once in ten years.	Gauge-readings for flood of 1882.
		Feet.		*Feet.*		*Feet.*	*Feet.*
0	Cairo	52.4	1883	−1.0	1871	51.5	51.8
240	Memphis	35.1	1882	−1.0	1872	34.5	35.8
306	Helena	47.2	1882	0.0	1872	46.5	47.2
393	White River	48.5	1882	0.0	1872	47.5	48.5
597	Vicksburg	51.1	1862	−1.8	1872	49.0	48.8
700	Natchez	50.8	1862	0.0	1872	48.0	47.9
764	Red River Landing	48.6	1882	0.0	1872	47.0	48.6
955	Carrollton	15.9	1862	−1.6	1872	15.6	15.0

If the figures in the last two columns of this table be compared, it will be seen that in five cases the flood of 1882 was higher than the flood that may be expected once in ten years, and in three cases lower, and that in the average of all it was 0.4 foot higher. Considering the smallness of this excess above the floods to be expected once in ten years, the fact that at four places out of eight the flood of 1882 was not the maximum flood observed in the last 20 or 25 years, and the probability that the height of floods will increase in the future, it seems proper that in the plan for any general system of levees, if the principle of keeping out all floods, whatever their height, should be surrendered (a step of doubtful advisability), the plan should at least provide for holding a flood like that of 1882.

In what follows, that flood will be the one considered.

Adopting the flood of 1882 as the one to be confined, the next question is what height of levees is necessary.

From the investigations of the Commission, the flow of the flood of 1882 at its maximum down the Mississippi Valley, whether in the river proper or in the bottom lands, is now at least approximately known. With a complete system of levees on the river banks, the whole of that flow would be confined between them.

The following table gives the approximate results of the observations of the Commission (many of them not yet published) which were made on the floods of 1882 and 1883:

Stations.	Maximum discharge observed in flood of 1882 in river proper.	Amount which was flowing down valley outside of river.	Total flow past.
	Cubic feet.	*Cubic feet.*	*Cubic feet.*
Columbus	1,600,000	200,000	1,800,000
Fulton (estimated from observations of 1880)	1,200,000	600,000	1,800,000
Helena	1,540,000	360,000	1,900,000
Hay's Landing	1,060,000	940,000	2,000,000
Red River Landing	1,600,000	600,000	2,200,000

Observations determining the relations between gauge-readings and corresponding discharges were made at several stations. If those gauge-readings be platted as ordinates and the corresponding discharges as abscissas, the resulting broken line which deviates somewhat from a right line is called a discharge curve. This discharge curve for the rising river is usually tolerably regular until the river gets above its banks, when it may become irregular and complicated from the escape of water over the banks and from variations in the slope of the main river, due to floods in tributaries or to return of water from the swamps into which it had previously escaped.

But if the river were leveed throughout its length, it seems probable, so far as the investigations of the Commission yet go, that at places unaffected by tributary flow the discharge curve for the confined river for all stages would be a continuation of that of the unconfined river for stages less than, or equal to, that at which escape over banks begins.

If this should be verified by a complete study of the subject, not yet made by the Commission, the method of determining the gauge reading at a place where discharge observations have been made which would pass a given discharge with the river thoroughly leveed, would be to prolong graphically the observed discharge curve, continuing it with the form it had before overflow began up till it corresponds to the desired discharge. The gauge reading corresponding to that discharge would be the corresponding height of the confined water surface.

These discharge curves at Columbus, Helena, Hay's Landing, and Red River Landing are given in the Commission's report for 1883. Any one can examine the result of prolonging them and form an idea of the new gauge heights, although different persons would differ somewhat in estimating their prolongations. From the discharge measurements and the observations of flood escape over river banks in the floods of 1882 and 1883, by Mr. Johnson and Mr. Stewart, it is known that in the flood of 1882 the maximum flow across the latitude of Columbus, Ky., was approximately 1,800,000 cubic feet per second, which at Red River Landing increased to about 2,200,000 cubic feet.

With a thorough system of levees these quantities would have been confined between the levees, and the question now is, how much would the levees have raised the river surface above the height it actually had in 1882?

At Columbus, Ky., overflow begins at about 95 feet on the gauge; a prolongation of the discharge curve in the way previously stated gives for a discharge of 1,800,000 cubic feet a stage about 3 feet above the flood of 1882.

A discharge curve for Fulton, Tenn., is given in the Commission report for 1881. A prolongation of that curve gives for 1,800,000 discharge a gauge reading of about 72 feet, or 10 feet above the flood of 1882.

The maximum discharge across the latitude of Helena, Ark., for the flood of 1882 may be taken as 1,900,000 cubic feet. Prolonging the Helena discharge-curve to this amount, the gauge reading is about 4 feet above high water of 1882.

At Hay's Landing, just below Lake Providence, the maximum discharge across its latitude in the flood of 1882 may be taken as 2,000,000 cubic feet. The discharge curve prolonged to this amount gives a gauge reading 10 feet above the flood of 1882.

At Red River Landing the question of flood height with high levees will depend on the amount of water that is allowed to escape down the Atchafalaya. The maximum observed discharge at Red River Landing in 1882 was 1,600,000 cubic feet. The estimated flow across the latitude of Red River Landing was 2,200,000, so that if 200,000 or 300,000 cubic feet were allowed to go down the Atchafalaya, the flow below Red River Landing would be 1,900,000 or 2,000,000 cubic feet, so that the raising of all the levees below Red River Landing would be necessary to hold this increase of 300,000 or 400,000 cubic feet per second.

Where there was a flow of from 500,000 to 900,000 cubic feet per second down the valley, outside of the river, in the flood of 1882, as was the case for long distances above and below Fulton and Lake Providence, there will be for long distances levees needed whose heights above the flood of 1882 will approach the heights of those needed at Lake Providence (or Hay's Landing) and Fulton.

A good system of levees should rise 3 feet above the expected heights of the confined water. No provision has been made for this in these remarks, because at several points the flood of 1882 was the highest of which we have accurate records, and in this paper it has not been proposed to confine the highest floods, although that is essential in a thorough and effective levee system.

Nor has the possible lowering of the river slope, which might occur some time after the building of the levees, been taken into account. The first effect of building levees would be to raise the flood surface. I know of no facts of experience which give data for determining either the amount of such ultimate lowering or the time required for it.

As stated by the Commission, a thorough study of the subject of levees has not yet been made; until then, accurate estimates are impossible, and the heights above the flood of 1882, of 3 feet at Columbus, 10 feet at Fulton, 4 feet at Helena, and 10 feet at Lake Providence, given above, are only approximations. Such as they are, they make it impossible for me to concur in the estimate of $11,443,770 as the cost of a general system of levees from Commerce, Mo., to the Forts, adequate to preserve that country from destructive floods.

C. B. COMSTOCK,
Lieutenant-Colonel of Engineers, and Brevet Brigadier-General,
President Mississippi River Commission.

NEW YORK, *December* 22, 1883.

The Hon. ROBT. T. LINCOLN,
Secretary of War.

(Through the Chief of Engineers.)

Itemized statement of expenditures for surveys and expenses of Mississippi River Commission.

[Appropriation of August 2, 1882.]

Items.	Services assistant engineers.	Services rodmen, &c.	Outfit.	Supplies.	Subsistence.	Fuel.	Repairs.	Transportation.	Mileage.	Miscellaneous.	Totals.
Commissioners salaries											$8,333 33
Mileage and inspection		$3,314 38	$8 17	$163 91	$1,849 80	$447 31		$14 50	$4,784 49	$79 87	10,661 93
Transverse valley curves	$1,475 00	3,453 00	35 13	16 97			$6 00	834 05		83 75	5,903 90
Dams at mouth Red River	130 00	282 25						40 55			452 80
Flood observations	46 00	1,722 06	6 00	132 40	421 47	612 80		1,293 25			4,233 98
Observations and gauges over entire river	4,410 00	8,917 16	69 52	646 16		1,067 84	966 50	991 25		172 00	17,240 43
Steamer and outfit											277 50
Contingencies											229 00
Re-examination of Atchafalaya	751 00	996 92	34 25	47 25		25 00		152 45		*1,394 90	3,401 77
Gauges	1,395 93	3,899 58	474 85	131 47	39 37	79 20	88 50	306 70		69 81	6,485 41
Tide-gauge connection	576 50	844 83		5 95			2 25	144 25		14 32	1,588 10
Precise levels	1,216 00	2,824 41	109 90	9 15			47 10	203 86		45 20	4,455 62
Reduction of field work	18,140 88	118 03	116 41	301 41			66 84	17 75			18,851 32
Reduction of maps											61 55
Publication of maps											3,510 75
Hydrography and topography	19,955 65	27,666 73	9,135 36	2,672 12	9,094 01	796 52	1,416 96	5,572 36		555 35	76,865 06
High and low water marks	995 27	808 60	603 36	72 15	178 25	27 46	62 31	287 65		7 00	3,042 05
Levee map	433 83										433 33
Totals	49,525 56	54,847 95	10,592 95	4,288 94	11,582 90	3,056 13	2,656 46	9,858 62	4,784 49	2,421 70	

Item.	Services assistant engineers.	Services clerks, &c.	Rent.	Fuel.	Prof. works and charts.	Furniture.	Drawing material and supplies.	Transportation.	Stationery.	Miscellaneous.	
Office	$180 00	$8,553 28	$1,200 00	$347 07	$45 88	$74 45	$499 41	$272 46	$532 13	$620 18	12,324 86
											178,352 69

* Line of levels run by contract at $10 per mile.

SUMMARY.

Balance from appropriation March 3, 1881	$38,005 72
Appropriated by act August 2, 1882	150,000 00
Cash deposited, sale of fuel to officers, and overpayment vouchers	188 50
Total	188,194 22
Expenditures for fiscal year ending June 30, 1883	178,352 69
Balance	9,841 53

SMITH S. LEACH,
First Lieutenant of Engineers, Secretary and Disbursing Officer Mississippi River Commission

TABLE OF TOTAL EXPENDITURES, CONSTRUCTION DEPARTMENT, MISSISSIPPI RIVER COMMISSION, FROM THE BEGINNING OF CONSTRUCTION UP TO NOVEMBER 1, 1883.

[Covering appropriations of March 3, 1881, and August 2, 1882.]

New Madrid Reach	$209,071	11
Plum Point Reach	1,406,216	85
Memphis Reach and Harbor	268,269	64
Lake Providence Reach	1,225,582	33
Vicksburg Harbor	44,522	40
Delta Point, La	49,992	36
Survey of Helena Reach	7,511	29
Survey of Saint Francis front, first district	3,312	91
Survey of Saint Francis front, second district	3,212	93
Survey of unleveed fronts, third district	496	96
Survey of unleveed fronts, fourth district	....	......
Survey of Cubitt's Gap	137	14
Choctaw Bend survey	2,679	86
Observations at Carrollton, La	3,000	00
Closing Bonnet Carré Crevasse	15,000	00

LEVEES.

Second District.

Yazoo front	79,832	25

Third District.

Tensas front	291,156	49
Yazoo front	313,836	32

Fourth District.

Atchafalaya front	102,947	22
Tensas front	251,630	81
Total	4,278,408	87

TABLE OF TOTAL EXPENDITURES FROM SPECIAL APPROPRIATIONS.

Natchez and Vidalia (June 30, 1882, to November 30, 1883)	$2,920	62
Mouth of Red River (to November 1, 1883)	51,970	66
New Orleans Harbor (July 1, 1882, to November 1, 1883)	38,414	90
Total	93,306	18
Total from all appropriations	4,371,715	05

Respectfully submitted.

CLINTON B. SEARS,
Captain Engineers, U. S. A.,
Secretary Construction Committee, Mississippi River Commission.

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APPENDICES.

APPENDIX A.

ANNUAL REPORT OF THE SECRETARY OF THE COMMISSION UPON THE FIELD WORK OF SURVEYS AND EXAMINATIONS.

OFFICE OF MISSISSIPPI RIVER COMMISSION,
2828 WASHINGTON AVENUE,
Saint Louis, November 13, 1883.

GENERAL: I have the honor to submit the following report of surveys and examinations during the fiscal year ending June 30, 1883:

Outfit.—During the year the fleet was increased to accommodate three topographical parties by the addition of two new boats, named the Illinois and Kentucky, counterparts, respectively, of the Mississippi and Louisiana.

The old boats have been thoroughly repaired, and the Pioneer enlarged. One of the iron launches was lost in a storm at Helena, about the end of October. After several days' search by a snag-boat, it was conceded to be impossible to recover it, and the attempt was abandoned.

The tug Mignon and survey boat Missouri were inspected by Captain Marshall on February 10, and his recommendations that the Missouri and the hull of the Mignon be abandoned, the machinery of the latter being taken out, having been approved by the Chief of Engineers, have been carried into effect.

Instruments.—The old instruments were thoroughly repaired, as noted in last report. The following have been purchased during the year: 4 transits, 3 Wye levels, 4 sextants, 3 prismatic compasses, 2 pedometers, 2 hand levels.

There have been transferred to this appropriation from that for the survey of Northern and Northwestern Lakes: 1 chronometer, 1 iron standard bar, 1 standard meter.

Organization and methods.—The only change to be noted is in the programme for precise leveling, in which the instructions have been so modified as to require that each observer shall duplicate his own work in opposite direction, so as to form a loop beginning and ending on the same bench. In this connection attention is invited to a report by Assistant L. L. Wheeler on cumulative errors, submitted herewith.

Progress and cost.—Precise levels were carried from Carrollton to the tide gauge at Biloxi, 87 miles; from Keokuk to Fulton, 171 miles; and from Fulton to Savannah, 21 miles. The last section is a part of the continuation of the line to Chicago, which has since been completed.

The cost of the work in the other sections was as follows:

Carrollton to Biloxi:	
Total field cost	$2,778 36
Cost per mile of duplicated work	31 93
Keokuk to Fulton:	
Total field cost	3,252 05
Cost per mile of duplicated work	19 08
Cost per mile of river	19 02
Average cost per mile of duplicated work for the two sections	23 46

The work on the Carrollton–Biloxi section was undertaken during the windy season on the Gulf coast, and, to meet this contingency, observing tents were provided. This was their first use in our work, and they were found of such great advantage that they have been employed on subsequent work, and have enabled much windy weather to be utilized.

This section was along a line of railroad, and a hand-car was kindly loaned by the company for transportation. It was found to so materially contribute to the progress of the party, that on subsequent work, lying along a railway line, a hand-car was purchased and added to the outfit of the party.

The tabulated results of the final computation for the above lines, and also for the line from Grafton to Keokuk, noted in the last annual report, are herewith submitted, with field reports by Assistants J. B. Johnson and J. A. Paige, and report on reduction by Assistant L. L. Wheeler.

Topography and hydrography was carried from Arkansas City to Greenville, 36 miles, and from Lake Providence to Donaldsonville, 353 miles; a total of 389 miles. Three parties were engaged on this work, and their performance may be summarized as follows:

First party, Assistant J. A. Ockerson, Arkansas City to Greenville, and Natchez to Bayou Sara:

Number of miles of river	136
Number of square miles of topography	321
Number of square miles of hydrography	75
Total area surveyed in square miles	396
Total field cost	$23,607 87
Cost per mile of river	173 59
Cost per square mile of survey	59 62

Second party, Assistant L. L. Wheeler, Warrenton to Natchez:

Number of miles of river	93
Number of square miles of topography	217
Number of square miles of hydrography	63
Total area surveyed in square miles	280
Total field cost	$17,879 41
Cost per mile of river	192 25
Cost per square mile of survey	63 86

In connection with the work of this party the sections of the previous survey, from Malone's to Australia, from Riverton to head of Ozark Island, from Bolivar to Cypress Creek, and from Mound Place to Arkansas City, were resounded.

The sections named are at and below the principal crevasses of the flood of 1882. This work comprised 21 square miles of hydrography, costing $57.65 per square mile.

Third party, Assistant C. M. Winchell, Lake Providence to Warrenton, and Bayou Sara to Donaldsonville:

Number of miles of river	160
Number of square miles of topography	370
Number of square miles of hydrography	89
Total area surveyed, square miles	459
Total field cost	$23,127 85
Cost per mile of river	144 54
Cost per square mile of survey	50 39
For the three parties:	
Total area surveyed, square miles	1,135
Cost per square mile	$56 93

Field reports on the above work by assistants Ockerson, Winchell, Wheeler, and Wood, H. B., are submitted herewith.

Transalluvial levels were completed on the following lines:

No. 5. Up Cypress Creek.
No. 6. Grand Lake to Bayou Maçon Hills.
No. 7. Lake Providence to Yazoo City.
No. 8. Saint Joseph, west to high land.
No. 9. Fort Adams to Avoyelles Prairie, and thence across Bayou Bœuf and Red River.

The total distance of 164 miles was accomplished in a season of 174 days.

The total field cost was $5,318.90, giving a cost per mile of $32.43.

A report, by Assistant E. S. Davis, of the entire work is submitted herewith.

Observations to determine the escape of water from the river were made from Cairo to Vicksburg at the top of the flood of 1883. Below Vicksburg the flood was not of sufficient magnitude to warrant the continuance of the observations.

Determination of high-water marks have been continued, and the low-water profile was extended from Commerce to Natchez.

The observation parties mentioned in last report as having begun work at Paducah, Columbus, Helena, Hays' Landing, and Red River Landing, continued the measurement of sections and discharges during a year, at the expiration of which they were disbanded. The results have been partially reduced, checked, and tabulated in the office, and are herewith submitted, together with reports of the chiefs of the parties at Paducah, Columbus, Hays' Landing, and Red River Landing.

To ascertain the effect of the closure of Bonnet Carré crevasse, a hydrographic survey of 6 miles in front of it was made in November, 1882. This survey is now, November, 1883, being repeated.

A resurvey of the Atchafalaya was made in December, 1882, and January, 1883, to determine by comparison with a previous survey, the amount of enlargement of that stream.

I am glad of another opportunity of bringing to the attention of the committee the zealous and efficient services rendered by the assistant engineers and other employés of the Commission.

The permanent force was somewhat increased during the year by the retention of the principal officers of the third topographical party. The grade of work has been higher than we have heretofore attained. This has been accompanied by a marked reduction of cost, due to the increase of rate. These gratifying results are largely due to the policy heretofore pursued, of so arranging the work in field and office as to admit of its being done by a comparatively small force, kept continuously employed.

The slight disadvantages which this system presents are repaid a hundred fold by the personal interest in, and enthusiasm for, the work shown by a very large majority of those engaged upon it; without which the results sets forth in this report would have been impossible.

A feature of the office work of the past year has been the successful substitution of printing from types for hand-lettering on our detail sheets. The cost is very much reduced, and the appearance of the charts improved. In this connection the services of Mr. J. A. Ockerson are deserving of especial mention.

For details of expenditures, the committee is respectfully referred to the itemized statement of expenditures submitted to the Commission.

Very respectfully, your obedient servant,

SMITH S. LEACH,
First Lieutenant of Engineers, Secretary.

To General C. B. COMSTOCK,
President Mississippi River Commission, and
Chairman Committee on Surveys and Examinactions.

APPENDIX B.

FINAL REPORT UPON A SECONDARY TRIANGULATION OF THE MISSISSIPPI RIVER BETWEEN CAIRO, ILL., AND KEOKUK, IOWA, EXECUTED UNDER THE ORDERS OF THE MISSISSIPPI RIVER COMMISSION, 1880-'81.

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., December 1, 1883.

GENERAL: I have the honor to submit herewith a memorandum compiled from the records of this office, relative to the secondary triangulation from Cairo to Keokuk, accompanied by the results in tabular form, and a sketch of the system, the whole intended to form a final report upon this portion of the work.

Very respectfully, your obedient servant,

SMITH S. LEACH,
First Lieutenant of Engineers, Secretary.

General C. B. COMSTOCK,
President Mississippi River Commission and
Chairman of Committee on Surveys and Examinations.

I.—The system is composed of 146 principal stations and 4 auxiliary stations, to connect the triangulation with the Chester and Cape Lacroix bases. Most of the stations are situated on the bluffs on either side of the valley. They are connected by 97 single triangles, 20 quadrilaterals, 3 pentagons, and 1 hexagon.

II.—The work depends on the following known lines:

1. A secondary base at Cairo, measured by a party of the United States Lake Survey. The length and azimuth of this base and the geodetic co-ordinates of its extremities were furnished by the office of that survey. Its length is 1,646.78 meters. (For description of this base, see Report of Chief of Engineers for 1877, Part II, page 1196.)

2. A secondary base at Chester. The length and azimuth of this base were determined by Assistant G. Y. Wisner in 1880. Its length is 3,255.07 meters.

3. The line Dryer-Insane Asylum, at Saint Louis. This line was furnished by the office of the Coast and Geodetic Survey. It depends for length and azimuth upon the American Bottom base, opposite Saint Louis, and for geodetic co-ordinates of its extremities, on the Saint Louis astronomical post. It is in the fifth triangle from the base. Its length is 13,331.3 meters.

4. A secondary base near Grafton, measured by Assistant Wisner in 1881. The

azimuth of a line near this base was determined, but not with sufficient accuracy to be used, except as a check. The length of the base is 2,031.61 meters.

5. A secondary base at Louisiana. The length and azimuth of this base were determined by Assistant Wisner in 1881. The base was connected with the Louisiana astronomical post. For description of this post, see Report of Chief of Engineers for 1879, page 1918. The base is 2,705.10 meters in length.

6. A secondary base at Keokuk, measured by Assistant Wisner in 1881. The azimuth of base was determined by Assistant John Eisenmann in same year. Its length is 1,297.38 meters.

A base was also measured, with steel tape, at Cape Lacroix, but was used only as a check.

III.—The following instruments were used:

Repsold universal instrument No. 1. Diameter of horizontal limb 10 inches.* Limb graduated to 4 minutes, reads by two microscopes to 2 seconds. Angles measured in order around the station, positive and negative, direct and reversed. Eight sets were taken uniformly distributed over the limb, giving 16 pointings at each station.

Troughton & Simms No. 1. Diameter of horizontal limb, 10 inches. Limb graduated to 5 minutes, reading by two microscopes to one second. Programme same as for Repsold.

Troughton & Simms No. 2 (of the Mississippi River Commission). Same as Troughton & Simms No. 1. Programme same as for Repsold.

Troughton & Simms No. 2 (of the Lake Survey). Diameter of horizontal limb, 12 inches. Limb graduated to 5 minutes reading, by two microscopes to one second. Programme same as for Repsold.

None of the instruments closed the horizon. The limit of closure of triangles was 6 seconds. The instruments were mounted on tripods of rough timber, which were left standing. The observer stood on a platform disconnected from the instrument support.

The stations were marked by stones 3 feet in length, dressed to 6 by 6 inches at one end, the balance rough. A small hole was drilled in the top. They were planted vertically, the top projecting but a few inches above ground.

The targets used in the triangulation from Cairo to Grafton were octagonal poles covered with alternate zones of black and white cloth. A nail in the bottom was set in the hole in the top of the marking stone, and the target was then plumbed. When the station was occupied the target was removed and reset before leaving.

For the greater part of the stretch from Grafton to Keokuk the target used consisted of four parallel wires fastened at bottom to a circular block by a wire ring, and fastened above by three other horizontal wire rings, which, with the block at bottom, divided the target into three sections. Strips of white cloth were fastened to opposite wires of the first and third sections, one strip to each section, and at right angles to each other. A strip of black cloth was fastened at an angle with the white strips to two auxiliary wires attached to the second and third rings.

This target gave no phase, and presented an illuminated surface whether the sun was before or behind it. To support the target a cross-piece was fastened to the top of the platform which supported the observer, and above the observer's head. A hole in the cross-piece was centered over the hole in the marking stone. A nail projecting from the block at bottom of target was placed in this hole, and the target was then plumbed and guyed to the corners of the platform. The target was not disturbed when the station was occupied.

IV.—For the preliminary reduction single triangles were adjusted to closure (quadrilaterals and pentagons were adjusted to satisfy local conditions), side and azimuth equations being neglected. The lengths and azimuths of sides were then computed for the stretches given below. The discrepancies were:

From—	To—	Number of triangles.	Discrepancies.	
			In length.	In azimuth.
				Obs.—comp. ″
Cairo	Chester	39	1: 6,000	+21.8
Chester	Saint Louis	23	1: 100,000	+ 9.3
Saint Louis	Grafton	35	1: 30,000	....
Grafton	Louisiana	22	1: 13,000	† −10.2
Louisiana	Keokuk	25	1: 25,000	+ 4.8

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* Erroneously stated as 12 inches in previous reports.

† Saint Louis to Louisiana.

The final reduction was made separately for each of the five stretches into which the work was divided by the six known lines before enumerated. It consisted of a least square adjustment, in which the observed lengths and azimuths of bases were assumed as correct, and all angles were given equal weight.

The conditions to be satisfied by the finally adjusted angles were that all triangles should close, and that the computed lengths and azimuths of bases should agree with their measured lengths and azimuths. The geodetic co-ordinates were then computed, all latitudes and longitudes being referred to the Cairo astronomical post.

The final discrepancies between the observed values of latitudes, longitudes, and azimuths and the corresponding values as computed from Cairo, are as follows:

	Latitude.	Longitude.	Azimuth.
	Obs.—comp. ″	*Obs.—comp.* ″	*Obs.—comp.* ″
Chester	*+6.13	....	−0.12
Saint Louis	+4.77	−2.90	+0.17
Louisiana	+1.56	−1.09	+0.04
Keokuk	....	....	−0.02

* Latitude at Chester only approximate.

A special report on the least square adjustment of the stretch from Cairo to Grafton, prepared by Assistant G. Y. Wisner, who made the computation, may be found in the Report of the Mississippi River Commission for 1882, page 62.

Tabulated results of secondary triangulation from Cairo to Keokuk.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
1	South Base	108 19 51.58	50.75	1,646.78	172 32 07.19	37 01 28.97	89 11 23.19
2	North Base	38 25 19.24	19.71	2,851.28	30 57 21.69	37 02 21.94	89 11 31.84
3	Bowles	33 14 50.76	49.55	1,866.65	244 11 35.51	37 01 02.61	89 12 31.18
		01.58	00.01				
2	North Base	71 57 02.60	01.33	2,851.28	30 57 21.69	....	....
3	Bowles	68 18 08.10	04.66	4,239.74	142 38 41.30	....	....
4	Taylor	39 44 55.05	54.04	4,143.21	282 52 44.56	37 02 51.98	89 14 15.28
		05.75	00.03				
3	Bowles	26 03 27.60	24.93	4,239.74	142 38 41.30	....	....
4	Taylor	69 01 27.70	25.54	1,869.71	253 36 13.06	....	....
5	Nimbus	84 55 08.64	09.55	3,974.38	348 41 47.25	37 03 09.04	89 13 02.69
		03.94	00.02				
4	Taylor	89 57 49.24	49.62	1,869.71	253 36 13.06	....	....
5	Nimbus	52 40 08.50	09.45	3,080.67	126 17 06.25	....	....
6	Dickey	37 21 59.04	60.94	2,449.59	343 38 06.61	37 04 08.17	89 14 43.21
		56.78	00.01				
4	Taylor	37 20 03.76	01.30	2,449.59	163 38 23.44	....	....
6	Dickey	63 15 12.28	11.24	1,511.30	46 53 17.85	....	....
7	Rowse	79 24 49.15	47.47	2,225.37	306 17 38.40	37 03 34.67	89 15 27.87
		05.19	00.01				
6	Dickey	84 45 43.33	43.71	1,511.30	46 53 17.85	....	....
7	Rowse	61 16 55.57	55.08	2,694.42	165 35 55.85	....	....
8	Murray	33 57 20.12	21.22	2,872.91	311 38 18.28	37 04 50.32	89 15 55.00
		59.02	00.01				
7	Rowse	33 24 07.12	06.37	2,694.42	165 35 55.85	....	....
8	Murray	86 09 12.54	13.43	1,705.18	71 44 52.92	....	....
9	Missouri Sister	60 26 40.00	40.21	3,090.50	312 10 53.60	37 04 41.99	89 17 00.56
		59.66	00.01				
8	Murray	35 17 40.47	40.71	1,705.18	71 44 52.02	....	....
9	Missouri Sister	116 21 33.05	33.02	2,075.03	135 22 40.37	....	....
10	Spiese's Mill	28 20 44.54	46.27	3,217.98	287 01 18.52	37 05 29.90	89 17 59.58
		58.06	00.00				
9	Missouri Sister	57 55 51.09	52.17	2,075.03	135 22 40.37	....	....
10	Spiese's Mill	68 25 11.05	13.33	2,183.28	23 47 18.12	....	....
11	Scudder	53 38 52.82	54.51	2,395.83	257 25 51.13	37 04 25.09	89 18 35.22
		54.96	00.01				
10	Spiese's Mill	58 17 21.17	20.01	2,183.28	23 47 18.12	....	....
11	Scudder	91 36 10.07	08.19	3,702.50	112 10 48.43	....	....
12	Promised Land	30 06 33.02	31.82	4,350.55	262 02 52.91	37 05 10.41	89 20 54.05
		04.26	00.02				

Tabulated results of secondary triangulation from Cairo to Keokuk—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′
10	Spiese's Mill	34 35 25.66	25.71	4,350.55	82 04 38.13		
12	Promised Land	115 14 33.92	33.71	4,914.90	146 48 19.20		
13	Atherton	30 09 59.13	60.63	7,830.76	296 37 12.82	37 07 23.82	89 22 42.65
		58.71	00.05				
12	Promised Land	42 27 04.71	04.94	4,914.90	146 48 19.20		
13	Atherton	39 52 28.35	30.01	3,347.86	6 39 43.46		
14	Goose Island	97 40 24.41	25.08	3,179.49	284 19 59.04	37 05 35.96	89 22 58.78
		57.47	00.03				
13	Atherton	84 57 52.40	53.52	3,347.86	6 39 43.46		
14	Goose Island	42 50 35.04	34.73	4,220.43	143 48 59.23		
15	Powers Island	52 11 31.22	31.77	2,880.96	271 36 26.57	37 07 26.46	89 24 39.71
		58.66	00.02				
13	Atherton	36 08 01.16	01.24	2,880.96	91 37 36.98		
15	Powers Island	86 28 50.35	50 12	2,010.96	185 07 36.45		
16	Burnham	57 28 07.66	08.65	3,410.67	307 39 32.19	37 08 21.48	89 24 32.43
		59.17	00.01				
15	Powers Island	55 54 43.28	42.91	2,010.96	185 07 36.45		
16	Burnham	82 06 10.50	11.35	2,489.67	87 13 52.19		
17	Commerce	41 59 05.30	05.75	2,977.70	309 11 57.11	37 08 27.52	89 26 13.19
		59.08	00.01				
16	Burnham	67 08 44.96	46.20	2,489.67	87 13 52.19		
17	Commerce	67 08 19.64	20.15	3,204.80	200 04 31.20		
18	Santa Fé	45 42 51.78	53.67	3,204.63	334 22 04.47	37 10 05.16	89 25 23.60
		56.38	00.02				
17	Commerce	43 31 21.05	20.33	3,204.80	200 04 31.20		
18	Santa Fé	70 07 32.83	33.52	2,409.26	90 12 31.65		
19	Hofner	66 21 06.20	06.17	3,290.22	336 32 38.83	37 10 05.44	89 27 06.35
		00.08	00.02				
18	Santa Fé	57 36 48.20	48.26	2,409.26	90 12 31.65		
19	Hofner	56 41 32.73	32.16	2,232.38	213 30 00.50		
20	Lassar	65 41 39.04	39.59	2,209.33	327 48 51.09	37 11 05.83	89 26 16.30
		59.97	00.01				
19	Hofner	58 12 37.53	37.72	2,232.38	213 30 00.50		
20	Lassar	83 40 18.54	19.91	3,074.00	117 10 50.59		
21	Uncle Joe	38 07 01.33	02.39	3,594.48	335 16 45.95	37 11 51.36	89 28 07.13
		57.40	00.02				
20	Lassar	33 42 06.83	06.24	3,074.00	117 10 50.59		
21	Uncle Joe	70 55 14.77	13.95	1,762.76	226 14 29.61		
22	Thebes	75 22 39.61	39.82	3,002.37	330 52 21.01	37 12 30.91	89 27 15.55
		01.21	00.01				
21	Uncle Joe	59 09 28.69	28.66	1,762.76	226 14 29.61		
22	Thebes	72 33 18.93	20.10	2,027.48	118 48 20.93		
23	Grand Chain	48 17 10.61	11.25	2,252.82	347 04 48.60	37 13 02.59	89 28 27.61
		58.23	00.01				
22	Thebes	61 30 41.12	42.17	2,027.48	118 48 20.93		
23	Grand Chain	73 28 01.25	01.63	2,519.18	225 19 35.71		
24	Day	45 01 14.45	16.21	2,747.74	00 19 03.47	37 14 00.04	89 27 14.96
		56.82	00.01				
22	Thebes	28 09 43.49	42.86	2,747.74	180 19 03.10		
24	Day	75 06 60.28	59.65	1,832.46	75 26 03.12		
24′	South Base	76 43 18.12	17.49	2,728.50	332 08 48.96	37 13 40.17	89 28 07.35
		01.89	00.00				
24	Day	58 51 29.88	29.71	1,832.46	75 26 03.12		
24′	South Base	54 16 54.38	54.20	1,240.22	201 08 37.27		
24″	North Base	66 51 36.26	36.09	1,176.47	314 17 15.39	37 14 26.09	89 27 49.10
		00.52	00.00				
23	Grand Chain	36 22 39.32	39.30	2,519.18	225 19 35.71		
24	Day	97 25 38.45	39.97	2,070.31	142 45 58.65		
25	Cape Lacroix	46 11 39.71	40.74	3,461.35	3 57 09.63	37 14 53.51	89 28 05.76
		57.48	00.01				
24	Day	58 40 03.66	03.26	2,070.31	142 45 59.65		
25	Capo Lacroix	62 40 45.80	47.41	2,070.64	260 04 41.47		
26	Sexton's	58 39 07.10	09.33	2,153.77	21 26 22.24	37 15 05.07	89 26 42.90
		56.56	00.00				

Tabulated results of secondary triangulation from Cairo to Keokuk—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	′ ″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
25	Cape Lacroix........	83 07 19.71	18.71	2,070.64	260 04 41.47	....	....
26	Sexton's..........	86 04 18.03	14.68	10,963.46	166 09 46.26	....	....
27	Floral........	10 48 24.28	26.66	11,016.98	356 57 08.36	37 20 50.38	89 28 29.53
		02.02	00.05				
26	Sexton's............	46 56 12.61	10.74	10,963.46	166 09 46.26	....	....
27	Floral...............	65 08 54.01	52.96	8,044.05	280 59 48.75	....	....
28	Clear Creek.........	67 54 56.38	56.52	10,735.88	33 08 21.30	37 19 56.75	89 22 44.84
		03.00	00.22				
27	Floral...............	46 41 44.33	42.94	8,644.05	280 59 48.75	....	....
28	Clear Creek.........	95 52 55.53	55.47	10,851.34	196 53 13.28	....	....
29	Bluff Lake..........	37 25 22.20	21.82	14.149.53	54 22 49.55	37 25 17.94	89 20 42.20
		02.06	00.23				
28	Clear Creek.........	45 36 26.92	26.69	10,351.34	196 56 13.28	....	....
29	Bluff Lake..........	85 49 16.72	17.85	9,865.18	102 46 45.58	....	....
30	Moccasin Springs...	48 34 15.11	15.72	13,769.21	331 17 03.42	37 26 28.54	89 27 13.57
		58.75	00.26				
29	Bluff Lake	38 58 55.32	56.36	9,865.18	102 46 45.58	....	....
30	Moccasin Springs...	89 10 21.69	22.39	7,892.25	103 32 25.31	....	....
31	Rich	51 50 39.49	41.45	12,544.28	321 42 29.64	37 30 37.42	89 25 58.33
		56.50	00.20				
30	Moccasin Springs...	42 46 36.39	36.66	7,892.25	193 32 25.31	....	....
31	Rich	82 26 58.37	60.05	6,561.56	96 00 11.14	....	....
32	Indian Creek........	54 46 22.35	23.42	9,577.75	330 43 52.75	37 30 59.60	89 30 24.06
		57.11	00.13				
31	Rich	49 40 11.50	11.31	6,561.56	96 00 11.14	....	....
32	Indian Creek........	102 12 07.34	06.61	10,609.97	173 45 22.72	....	....
33	Silica	28 07 41.20	42.25	13,603.45	325 37 11.79	37 36 41.72	89 31 11.11
		00.04	00.17				
32	Indian Creek........	49 50 51.61	50.11	10,609.97	173 45 22.72	....	....
33	Silica...............	55 37 47.49	45.46	8,414.61	298 07 08.58	....	....
34	Big Muddy..........	74 31 25.60	24.62	9,086.99	43 38 48.47	37 34 32.97	89 26 08.67
		04.70	00.19				
33	Silica...............	107 18 01.20	01.48	8,414.61	298 07 08.58	....	....
34	Big Muddy..........	38 22 06.69	07.74	14,245.30	156 32 20.83	....	....
35	Fountain Bluff	34 19 50.18	50.97	9,261 35	10 49 50.45	37 41 36.77	89 30 00.16
		58.07	00 19				
34	Big Muddy..........	35 09 37.54	38.60	14,245.30	156 32 20.83	....	....
35	Fountain Bluff......	65 21 15.42	16.20	8,343.58	271 08 43.28	....	....
36	Swallow Rock.......	79 29 03.67	05.47	13,168.78	11 43 05.99	37 41 31.23	89 24 19.67
		56.63	00.27				
35	Fountain Bluff	75 43 59.24	59.09	8,343.58	271 08 43.28	....	....
36	Swallow Rock.......	54 17 47.80	48.24	10,560.46	145 29 59.70	....	....
37	Worthen	49 58 11.70	12.85	8,848 50	15 25 42.99	37 46 13.45	89 28 24.07
		58.74	00.18				
35	Fountain Bluff......	83 11 18.03	17.47	8,848.50	195 24 44.19	....	....
37	Worthen	65 49 39.68	40.26	17,066.99	81 15 23.25	....	....
38	Backbone	30 59 00.62	02.62	15,681.23	292 07 23.96	37 44 48.74	89 39 53.09
		58.33	00.35				
37	Worthen	29 46 57.20	57.79	17,066.99	81 15 23.25	....	....
38	Backbone	69 23 07.65	06.55	8,587.07	191 45 14.79	....	....
39	O'Harrah	80 49 57.19	56.01	16,180.86	290 56 02.60	37 49 21.42	89 38 41.57
		02.04	00.35				
38	Backbone	72 28 46.17	47.92	8,587.07	191 45 14.79	....	....
39	O'Harrah	68 39 58.40	60.42	13,053.34	80 25 59.04	....	....
40	Killion	38 51 11.69	11.92	12,750.39	299 11 48.88	37 48 10.73	89 47 27.73
		56.26	00.26				
39	O'Harrah............	37 54 52.30	52.99	13,053.34	80 25 59.04	....	....
40	Killion	49 42 14.13	18.58	8,028.04	210 38 17.88	....	....
41	Manskear	92 22 45.92	48.63	9,962.43	298 17 11.91	37 51 54.74	89 44 40.35
		52.35	00.20				
40	Killion	36 32 10.16	14.62	8,028.04	210 38 17.88	....	....
41	Manskear...........	50 19 06.08	05.64	4,780.68	340 20 54.90	....	....
41′	Lower Base	93 08 39.19	39.82	6,187.72	67 12 55.46	37 49 28.52	89 43 34.58
		55.43	00.08				

Tabulated results of secondary triangulation from Cairo to Keokuk—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	′ ″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
40	Killion	31 27 43.01	44.26	6,187.72	247 10 32.49		
41′	Lower Base	65 42 35.84	36.41	3,255.07	132 55 31.86		
41″	Upper Base	82 49 37.48	39.38	5,684.44	35 44 11.45	37 50 40.41	89 45 12.02
		56.33	00.05				
40	Killion	40 08 30.09	28.32	8,024.04	210 38 17.88		
41	Manskear	94 20 30.40	28.53	7,253.98	125 00 29.07		
42	Chester	45 31 03.67	03.30	11,219.89	350 29 03.03	37 54 09.65	89 48 43.55
		04.16	00.15				
40	Killion	48 41 53.59	55.01	11,219.89	170 29 49.56		
42	Chester	74 08 16.48	16.32	10,031.77	64 37 19.35		
43	Rozier	57 09 47.76	48.94	12,845.01	301 43 20.60	37 51 50.08	89 54 54.35
		57.83	00.27				
42	Chester	29 49 27.47	28.75	10,031.77	64 37 19.35		
43	Rozier	114 20 18.69	19.37	8,521.73	130 13 12.29		
44	Vanse	35 50 10.80	12.08	15,611.56	274 20 16.62	37 54 48.48	89 59 20.78
		56.96	00.20				
43	Rozier	53 15 22.23	22.14	8,521.73	130 13 12.29		
44	Vanse	78 03 51.68	51.00	9,092.33	232 06 37.69		
45	Kaskaskia	48 40 47.14	47.05	11,101.40	3 28 51.87	37 57 49.48	89 54 26.77
		01.05	00.19				
44	Vanse	50 42 30.88	31.92	9,092.33	232 06 37.69		
45	Kaskaskia	83 48 33.79	35.43	9,869.12	135 58 13.85		
46	Reagan	45 28 51.24	52.88	12,677.47	1 24 13.60	38 01 39.48	89 59 08.01
		55.91	00.23				
44	Vanse	39 27 22.73	21.59	12,677.47	181 24 05.78		
46	Reagan	73 38 02.33	01.78	8,757.93	75 02 15.38		
47	Correll	66 54 38.04	36.90	13,223.07	321 53 18.67	38 00 26.00	90 04 54.83
		03.10	00.27				
46	Reagan	44 46 36.92	38.01	8,757.93	75 02 15.38		
47	Correll	54 11 06.79	07.29	6,244.91	200 47 34.48		
48	Brewerville	81 02 13.72	14.81	7,189.71	299 46 15.70	38 03 35.35	90 03 23.89
		57.43	00.11				
47	Correll	73 19 06.22	06.65	6,244.91	200 47 34.48		
48	Brewerville	57 17 38.95	39.97	7,880.26	78 06 10.47		
49	Magnolia	49 23 12.47	13.49	6,922.23	307 26 09.04	38 02 42.54	90 08 40.18
		57.64	00.11				
47	Correll	35 25 13.94	14.64	6,922.23	127 28 27.83		
49	Magnolia	112 52 41.02	41.10	7,634.70	194 33 27.94		
50	County Line	31 42 03.69	04.38	12,136.64	342 52 12.14	38 06 42.21	90 07 21.36
		58.65	00.12				
49	Magnolia	67 09 09.98	09.40	7,634.70	194 33 27.94		
50	County Line	56 24 08.98	09.01	8,442.63	70 58 25.53		
51	Brickey	56 26 42.32	41.73	7,630.95	307 21 45.18	38 05 12.82	90 12 48.87
		01.28	00.14				
50	County Line	58 41 09.09	08.79	8,442.63	70 58 25.53		
51	Brickey	72 16 13.48	12.34	9,550.64	178 38 51.10		
52	Kidd	49 02 38.69	39.06	10,648.12	309 36 06.32	38 10 22.49	90 12 58.13
		01.26	00.19				
51	Brickey	43 00 37.90	37.55	9,550.64	178 38 51.10		
52	Kidd	81 49 55.06	56.27	7,937.86	80 28 41.65		
53	Cæsar's	55 09 25.90	26.37	11,518.81	315 34 49.81	38 09 39.78	90 18 19.70
		58.86	00.19				
52	Kidd	65 19 59.21	58.27	7,937.86	80 28 41.65		
53	Cæsar's	62 59 02.25	00.69	9,193.88	197 26 22.25		
54	Weisenborn	51 41 02.16	01.20	9,013.07	325 46 31.12	38 14 24.24	90 16 26.40
		03.62	00.16				
53	Cæsar's	46 32 53.42	54.70	9,193.88	197 26 22.25		
54	Weisenborn	83 16 02.46	04.36	8,689.44	100 43 36.68		
55	Herculaneum	50 10 59.87	61.14	11,887.10	330 51 00.44	38 15 16.55	90 22 17.54
		55.75	00.20				
54	Weisenborn	61 59 42.94	43.04	8,689.44	100 43 36.68		
55	Herculaneum	55 46 00.56	00.03	8,069.98	224 53 59.27		
56	Salt Bluff	62 14 17.00	17.09	8,118.54	342 42 18.24	38 18 35.65	90 18 05.66
		00.50	00.16				

Tabulated results of secondary triangulation from Cairo to Keokuk—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
55	Herculaneum	47 20 16.23	16.48	8,669.98	224 53 59.27	....	....
56	Salt Bluff...........	62 24 32.64	33.50	6,773.94	107 21 08.83	....	....
57	Sulphur Springs	70 15 09.91	10.15	8,164.13	357 33 33.93	38 19 41.09	90 22 31.84
		58.78	00.13				
56	Salt Bluff...........	61 00 22.41	24.59	6,773.94	107 21 08.83	....	....
57	Sulphur Springs......	81 19 49.20	51.50	9,697.15	205 58 32.28	....	....
58	Meramec	37 39 43.94	44.07	10,959.89	348 20 36.86	38 24 23.78	90 19 36.79
		55.55	00.16				
56	Salt Bluff...........	39 36 46.72	45.92	10,959.89	168 21 33.42	....	....
58	Meramec............	43 33 15.78	14.73	7,037.96	304 47 22.13	....	....
59	Bocan	96 49 60.52	59.49	7,605.82	27 59 50.50	38 22 13.48	90 15 38.69
		03.02	00.14				
58	Meramec............	50 52 43.93	43.67	7,037.96	304 47 22.13	....	....
59	Bocan	78 36 30.82	31.15	7,074.89	203 26 21.14	....	....
60	Gummershimer	50 30 45.56	45.30	8,939.68	73 58 18.51	38 25 43.98	90 18 42.67
		00.31	00.12				
59	Bocan	41 07 51.06	51.46	7,074.89	203 26 21.14	....	....
60	Gummershimer	90 22 19.62	20.62	6,213.95	113 49 53.82	....	....
61	Twin Hollow........	48 29 47.63	48.03	9,446.62	342 17 16.12	38 27 05.35	90 17 37.08
		58.31	00.11				
60	Gummershimer	83 55 59.62	60.73	6,213.95	113 49 53.82	....	....
61	Twin Hollow........	57 48 55.88	56.39	9,980.80	235 58 31.70	....	....
62	Dryer	38 15 02.50	03.01	8,494.69	17 47 01.09	38 30 06.33	90 11 55.71
		58.00	00.13				
60	Gummershimer	49 12 45.46	45.76	8,494.69	197 45 54.55	....	....
62	Dryer	79 24 46.99	47.88	8,232.67	97 11 48.97	....	....
63	Forder	51 22 26.24	26,53	10.688.27	328 30 45.61	38 30 39.64	90 17 32.83
		58.69	00.17				
62	Dryer	51 05 01.70	01.86	8,232.67	97 11 48.97	....	....
63	Forder	90 46 60.43	59.99	10,373.58	186 21 19.09	....	....
64	Insane Asylum......	38 07 58.81	58.37	13,331.28	328 13 50.30	38 36 13.99	90 16 45.37
		00.94	00.22				
62	Dryer	84 03 52.91	53.73	13,331.28	148 16 50.83	....	....
64	Insane Asylum......	49 47 08.37	09.19	18,387.10	278 26 41.11	....	....
65	Clark's Mound	46 08 56.66	57.55	14,116.73	52 25 32.25	38 34 45.75	90 04 13.97
		57.94	00.47				
64	Insane Asylum......	58 44 17.72	17.70	18,387.10	278 26 41.11	....	....
65	Clark's Mound	81 29 45.00	45.03	15,717.51	130 04 14.84	....	....
66	Stand Pipe.........	39 45 57.62	57.65	9,606.16	39 45 01.92	38 40 13.59	90 12 31.51
		00.34	00.38				
65	Clark's Mound	71 47 17.96	18.51	15,717.51	130 04 14.84	....	....
66	Stand Pipe..........	51 12 27.59	28.44	17,801.48	258 46 35.83	....	....
67	Sugar Loaf.........	57 00 12.78	13.60	14,606.56	21 53 53.89	38 42 05.33	90 00 28.91
		58.33	00.55				
66	Stand Pipe..........	68 30 09.14	08.15	17,801.48	258 46 35.83	....	....
67	Sugar Loaf..........	33 08 35.94	36.81	16,911.19	112 02 44.30	....	....
68	Robinson............	78 21 16.07	15.46	9,937.31	10 17 13.59	38 45 30.68	90 11 18.10
		01.15	00.42				
66	Stand Pipe..........	35 09 57.67	57.38	9,937.31	190 16 27.68	....	....
68	Robinson............	48 28 12.54	12.36	5,758.84	321 49 01.23	....	....
69	Soechtig	96 21 50.56	50.37	7,485.29	45 28 43.07	38 43 03.85	90 08 50.74
		00.77	00.11				
68	Robinson............	73 34 35.54	36.97	5,758.84	321 49 01.23	....	....
69	Soechtig	38 11 55.30	55.63	5,948 35	180 02 30.08	....	....
70	Pettingill	68 13 24.98	26.45	3,834.90	68 15 56.64	38 46 16.76	90 08 50.56
		55.82	00.03				
68	Robinson............	33 07 51.71	51.80	3,834.90	248 14 24.26	....	....
70	Pettingill	107 58 35.98	36.21	3,338.31	176 14 32.85	....	....
71	Terrapin............	38 53 31.69	32.02	5,809.73	35 07 59.19	38 48 04.79	90 08 59.63
		59.38	00.03				
70	Pettingill	40 06 31.22	32.68	3,338.31	176 14 32.85	....	....
71	Terrapin............	88 23 24.31	25.86	2,748.00	267 51 01.31	....	....
72	Moore...............	51 29 59.86	61.48	4,263.92	36 22 11.14	38 48 08.12	90 07 05.82
		55.39	00.02				

Tabulated results of secondary triangulation from Cairo to Keokuk—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
71	Terrapin	30 24 58.64	58.44	2,748.09	267 51 01.31	....	....
72	Moore	45 18 14.17	14.11	1,435.66	133 10 26.73	....	....
73	Missouri River	104 16 47.54	47.46	2,015.76	57 26 46.99	38 48 39.97	90 07 49.21
		00.35	00.01				
72	Moore	63 29 37.60	36.82	1,435.66	133 10 26.73	....	....
73	Missouri River	86 14 42.46	41.73	2,549.36	226 55 17.81	....	....
74	Gillan	30 15 42.05	41.46	2,842.70	16 40 24.74	38 49 36.43	90 06 32.02
		02.11	00.01				
73	Missouri River	37 32 38.94	38.88	2,549.36	226 55 17.81	....	....
74	Gillan	104 29 09.23	09.27	2,525.02	151 25 15.47	....	....
75	Shirley	37 58 11.71	11.87	4,011.91	9 22 55.92	38 50 48.33	90 07 22.12
		59.88	00.02				
74	Gillan	32 00 57.88	58.43	2,525.02	151 25 15.47	....	....
75	Shirley	65 34 18.65	19.34	1,350.49	265 50 24.72	....	....
76	Gesler	82 24 41.55	42.24	2,319.29	3 26 17.52	38 50 51.51	90 06 26.25
		58.08	00.01				
75	Shirley	111 01 06.72	07.26	1,350.49	265 50 24.72	....	....
76	Gesler	36 48 03.92	04.61	2,367.02	122 39 04.36	....	....
77	Ringering	32 10 47.67	48.14	1,519.01	334 49 00.65	38 51 32.91	90 07 48.91
		58.31	00.01				
75	Shirley	37 04 16.14	16.83	1,519.01	154 49 17.46	....	....
77	Ringering	111 41 31.95	32.49	1,765.77	86 30 33.14	....	....
78	Freeman	31 14 09.32	10.69	2,721.80	297 43 57.97	38 51 29.42	90 09 02.01
		57.41	00.01				
77	Ringering	58 13 15.31	14.81	1,765.77	86 30 33.14	....	....
78	Freeman	72 01 60.25	59.82	1,966.83	194 27 47.46	....	....
79	Russell	49 44 45.76	45.38	2,200.86	324 43 14.86	38 52 31.18	90 08 41.63
		01.32	00.01				
78	Freeman	48 05 30.53	29.11	1,966.83	194 27 47.46	....	....
79	Russell	97 14 58.68	57.34	2,573.85	111 42 57.58	....	....
80	Glass Works	34 39 34.78	33.56	3,430.84	326 21 28.88	38 53 02.06	90 10 20.84
		03.99	00.01				
79	Russell	37 16 43.81	43.39	2,573.85	111 42 57.58	....	....
80	Glass Works	82 10 49.50	49.18	1,790.45	13 52 44.50	....	....
81	Watkins	60 32 27.70	27.44	2,928.55	254 25 00.76	38 52 05.69	90 10 38.65
		01.01	00.01				
80	Glass Works	72 15 44.93	45.25	1,790.45	13 52 44.50	....	....
81	Watkins	61 22 25.59	25.85	2,356.31	132 30 07.46	....	....
82	Strong	46 21 48.51	48.91	2,171.51	266 07 33.32	38 52 57.31	90 11 50.73
		59.03	00.01				
80	Glass Works	30 10 34.97	35.94	2,171.51	86 08 29.75	....	....
82	Strong	66 47 50.15	51.25	1,099.69	199 19 42.07	....	....
83	Alton	83 01 31.69	32.82	2,010.75	296 18 18.73	38 53 30.96	90 11 35.62
		56.81	00.01				
82	Strong	34 06 46.40	44.83	1,099.69	199 19 42.07	....	....
83	Alton	112 32 09.62	09.18	1,121.77	131 52 00.73	....	....
84	Saw Mill	33 21 04.85	05.99	1,847.50	345 12 44.95	38 53 55.24	90 12 10.29
		00.87	00.00				
82	Strong	29 31 16.35	15.08	1,847.50	165 12 57.24	....	....
84	Saw Mill	111 25 50.62	52.13	1,445.05	96 38 37.08	....	....
85	Nicholson	39 02 52.32	52.80	2,729.91	315 40 52.48	38 54 00.65	90 13 09.85
		59.29	00.01				
84	Saw Mill	36 39 16.09	15.86	1,445.05	96 38 37.08	....	....
85	Nicholson	100 17 57.97	57.84	1,263.83	176 20 01.84	....	....
86	Hop Hollow	43 02 46.33	46.30	2,082.90	313 17 13.43	38 54 41.55	90 13 13.21
		00.39	00.00				
85	Nicholson	63 11 33.17	33.85	1,263.83	176 20 01.84	....	....
86	Hop Hollow	80 17 47.36	47.02	1,895.88	76 37 46.75	....	....
87	Weper	36 30 38.33	39.14	2,093.78	293 07 37.81	38 54 27.33	90 14 29.76
		58.86	00.01				
86	Hop Hollow	47 36 04.34	01.50	1,895.88	76 37 46.75	....	....
87	Weper	56 43 03.61	03.06	1,444.92	199 53 55.61	....	....
88	Hull	75 40 58.03	55.44	1,635.72	304 13 12.99	38 55 11.39	90 14 09.35
		05.98	00.00				

Tabulated results of secondary triangulation from Cairo to Keokuk—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	′ ″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
87	Weper	86 46 56.95	57.84	1,444.92	199 53 55.61		
88	Hull	62 29 11.24	12.13	2,823.16	82 23 20.56		
89	Barwise	30 43 49.01	50.04	2,507.82	293 05 57.63	38 54 59.25	90 16 05.50
		57.20	00.01				
88	Hull	35 00 16.85	14.33	2,823.16	82 23 20.56		
89	Barwise	102 36 47.39	45.00	2,402.44	159 45 22.59		
90	Reihl	42 23 03.00	00.69	4,087.04	297 22 00.21	38 56 12.34	90 16 40.01
		07.24	00.02				
89	Barwise	41 11 36.23	35.61	2,402.44	159 45 22.59		
90	Reihl	105 46 02.28	01.76	2,902.04	85 31 02.66		
91	Eagle's Nest	33 02 23.04	22.65	4,240.58	298 32 09.82	38 56 04.97	90.18 40.13
		01.55	00.02				
90	Reihl	37 59 22.89	22.85	2,902.04	85 31 02.66		
91	Eagle's Nest	103 11 27.69	28.26	2,849.52	8 41 15.43		
92	Echele	38 49 08.25	08.91	4,507.30	227 30 13.12	38 54 33.62	90 18 58.00
		58.33	00.02				
91	Eagle's Nest	50 51 30.83	29.13	2,849.52	8 41 15.43		
92	Echele	73 11 21.10	19.46	2,667.27	115 29 44.75		
93	Portage	55 57 13.01	11.43	3,292.06	239 31 30.55	38 55 10.84	90 20 37.93
		04.94	00.02				
92	Echele	39 45 07.65	07.09	2,667.27	115 29 44.75		
93	Portage	97 54 14.82	14.35	2,532.17	197 34 27.63		
94	Starr	42 20 38.94	38.58	3,922.21	335 14 08.99	38 56 29.12	90 20 06.18
		01.41	00.02				
93	Portage	85 44 45 08	45.82	2,532.17	197 34 27.63		
94	Starr	52 21 28.20	27.97	3,781.47	69 56 15.54		
95	Pourie	41 53 44.83	46.23	3,002.59	291 48 29.10	38 55 47.08	90 22 33.65
		58.11	00.02				
94	Starr	48 06 02.76	02.90	3,781.47	69 56 15.54		
95	Pourie	58 48 22.80	22.53	2,941.78	191 06 20.33		
96	Elsah	73 05 35.04	34.59	3,380.88	298 01 00.53	38 57 20.64	90 22 10.12
		00.60	00.02				
95	Pourie	80 14 53.69	54.81	2,941.78	191 06 20.33		
96	Elsah	66 17 00.09	01.21	5,257.37	77 23 36.33		
97	East Base	33 28 02.76	04.02	4,883.94	290 49 26.42	38 56 43.38	90 25 48.16
		56.54	00.04				
96	Elsah	27 29 05.73	06.27	5,257.37	77 23 36.33		
97	East Base	111 21 34.13	34.83	3,686.92	145 59 47.57		
98	Grafton	41 09 18.15	18.95	7,439.97	284 49 34.76	38 58 22.48	90 27 08.82
		58.01	00.05				
97	East Base	82 11 48.38	48.09	3,686.92	145 59 47.57		
98	Grafton	30 32 38.63	37.61	3,960.66	356 31 31.32		
99	West Base	67 15 33.10	34.32	2,031.61	243 47 11.91	38 56 14.28	90 26 58.85
		59.81	00.02				
98	Grafton	93 13 05.97	06.27	3,960.66	356 31 31.32		
99	West Base	41 18 38.26	39.24	5,547.00	135 12 58.34		
100	Rivermouth	45 28 14.35	14.53	3,607.61	269 43 01.77	38 58 21.92	90 29 41.17
		58.58	00.04				
99	West Base	67 19 11.20	11.22	5,547.00	135 12 58.34		
100	Rivermouth	68 37 51.04	49.77	7,361.12	23 49 06.07		
101	Point Landing	44 02 58.92	59.11	7,429.57	247 50 47.62	38 54 43.53	90 31 44.55
		01.16	00.10				
100	Rivermouth	75 30 15.96	15.48	7,361.12	23 49 06.07		
101	Point Landing	31 55 21.75	22.22	7,469.66	171 52 26.29		
102	Thompson	72 34 22.34	22.37	4,079.65	279 17 36.35	38 58 43.32	90 32 28.42
		00.25	00.07				
101	Point Landing	63 56 41.36	41.85	7,469.66	171 52 26.29		
102	Thompson	34 59 37.55	37.49	6,793.04	26 51 36.21		
103	Calhoun	81 03 39.90	40.73	4,336.42	287 53 56.85	38 55 26.78	90 34 35.83
		58.81	00.07				
102	Thompson	63 31 32.71	31.48	6,793.04	26 51 36.21		
103	Calhoun	60 15 45.06	45.77	7,316.41	146 34 30.35		
104	Droege	56 12 43.34	42.86	7,097.16	270 20 02.23	38 58 44.77	90 37 23.26
		01.11	00.11				

Tabulated results of secondary triangulation from Cairo to Keokuk—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
103	Calhoun	32 57 50.07	50.23	7,316.41	146 34 30.35		
104	Droege	70 02 56.18	55.10	4,085.86	36 35 40.19		
105	Keel	76 59 14.53	14.74	7,058.55	293 33 51.32	38 56 58.38	90 39 04.41
		00.78	00.07				
104	Droege	69 22 37.25	37.08	4,085.86	36 35 40.19		
105	Keel	58 46 31.04	81.87	4,862.89	157 48 04.71		
106	Cahill	51 50 50.64	51.09	4,443.20	285 56 25.61	38 59 24.38	90 40 20.75
		58.93	00.04				
105	Keel	38 06 12.65	11.93	4,862.89	157 48 04.71		
106	Cahill	110 23 29.33	28.49	5,742.28	88 10 45.19		
107	Winfield	31 30 18.81	19.65	8,722.42	299 38 34.80	38 59 18.39	90 44 19.22
		00.79	00.07				
106	Cahill	88 55 44.86	44.32	5,742.28	88 10 45.19		
107	Winfield	44 26 45.67	45.41	7,898.57	223 41 29.74		
108	Wilson	46 37 29.57	30.35	5,531.83	357 06 22.20	39 02 23.54	90 40 82.35
		00.10	00.08				
106	Cahill	55 10 00.17	00.16	5,531.83	177 06 29.51		
108	Wilson	80 44 14.40	13.96	6,525.16	77 50 36.16		
109	Kilham	44 05 45.05	45.97	7,845.93	301 53 35.12	39 01 38.90	90 44 57.54
		59.62	00.09				
108	Wilson	109 36 25.36	23.72	6.525.16	77 50 36.16		
109	Kilham	37 30 52.59	52.37	11,322.93	220 16 56.78		
110	Peets	32 52 44.64	44.02	7,319.65	7 27 24.78	39 06 18.90	90 39 52.86
		02.59	00.11				
109	Kilham	47 50 36.15	34.93	11,322.93	220 16 56.78		
110	Peets	42 29 26.50	26.63	8,393.93	82 49 35.43		
111	Knox	89 39 58.85	58.61	7,648.44	352 25 55.46	39 05 44.76	90 45 39.42
		01.50	00.17				
110	Peets	79 33 48.23	48.07	8,393.93	82 49 35.43		
111	Knox	69 20 02.13	01.86	15,980.34	193 25 54.99		
112	Hamburg	31 06 10.62	10.39	15,203.58	342 21 22.36	39 14 08.76	90 43 04.64
		00.98	00.32				
111	Knox	31 25 42.49	40.65	15,980.34	193 25 54.99		
112	Hamburg	88 55 29.94	30.19	9,656.13	102 23 02.94		
113	Saltpeter	59 38 48.15	49.55	18,515.46	341 57 43.64	39 15 15.73	90 49 37.99
		00.58	00.39				
112	Hamburg	53 01 33.22	32.50	9,656.13	102 23 02.94		
113	Saltpeter	89 21 55.07	56.55	12,640.96	192 56 57.54		
114	Belleview	37 36 30.56	31.26	15,821.88	335 21 41.24	39 21 55.20	90 47 39.66
		58.85	00.31				
113	Saltpeter	41 23 36.16	37.72	12,640.96	192 56 57.54		
114	Belleview	82 13 05.78	04.66	10,036.63	95 11 17.16		
115	Clarksville	56 23 17.90	17.94	15,038.92	331 30 10.22	39 22 24.42	90 54 37.25
		59.84	00.32				
114	Belleview	43 38 49.53	47.84	10,036.63	95 11 17.16		
115	Clarksville	100 53 45.52	45.19	11,941.68	174 13 07.09		
116	Long	35 27 27.66	27.27	16,989.65	318 45 07.86	39 28 49.67	90 55 27.58
		02.71	00.30				
115	Clarksville	46 44 26.79	25.51	11,941.68	174 13 07.09		
116	Long	89 57 35.99	39.56	12,680.93	84 10 14.69		
117	Salt River	43 17 55.19	55.31	17,412.73	307 22 34.49	39 28 07.58	91 04 15.33
		57.97	00.38				
116	Long	46 03 22.94	25.58	12,680.93	84 10 14.69		
117	Salt River	44 24 05.39	05.28	9,130.96	308 28 44.46		
118	McLean	89 32 28.79	29.35	8,872.89	218 04 23.65	39 25 03.24	90 59 16.52
		57.12	00.21				
117	Salt River	61 16 28.52	28.32	9,130.96	308 28 44.46		
118	McLean	30 00 55.61	56.03	8,009.27	158 32 50.33		
119	Inner Base	88 42 35.69	35.74	4,568.79	67 14 08.18	39 29 04.94	91 01 19.09
		59.82	00.09				
117	Salt River	34 55 30.33	29.02	4,568.79	247 12 16.14		
119	Inner Base	40 17 52.28	52.54	2,705.10	26 56 15.64		
120	Outer Base	104 46 39.16	38.46	8,056.00	102 09 04.63	39 27 46.74	91 02 10.35
		01.77	00.02				

Tabulated results of secondary triangulation from Cairo to Keokuk—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	′ ″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
118	McLean	30 49 13.08	13.98	8,009.27	158 32 50.33		
119	Inner Base	62 14 05.84	06.74	4,109.40	40 45 39.18		
121	Louisiana	86 56 38.44	39.85	7,097.23	307 41 07.19	39 27 23.99	91 03 11.31
		57.36	00.07				
117	Salt River	100 00 02.93	01.90	9,130.96	308 28 44.46		
118	McLean	41 50 56.36	55.41	14,556.82	170 22 49.71		
122	Rockport	38 09 05.13	02.92	9,861.65	28 30 47.88	39 32 48.61	91 00 58.40
		04.42	00.23				
117	Salt River	67 05 14.00	13.73	9,861.65	208 28 42.59		
122	Rockport	83 16 03.87	04.61	18,364.53	111 46 52.49		
123	Red House	29 38 42.67	42.08	19,800.18	321 17 59.16	39 36 28.96	91 12 53.24
		00.54	00.42				
122	Rockport	32 05 49.55	50.16	18,364.53	111 46 52.49		
123	Red House	50 46 43.33	42.63	9,834.05	240 52 34.45		
124	Gard	97 07 27.35	27.60	14,337.82	323 48 56.68	39 39 03.99	91 06 52.91
		00.23	00.39				
123	Red House	75 11 46.20	45.78	9,834.05	240 52 34.45		
124	Gard	72 25 22.71	22.62	17,753.07	133 21 46.90		
125	See Horn	32 22 52.17	52.02	17,505.28	345 38 52.52	39 45 38.88	91 15 55.13
		01.08	00.42				
124	Gard	30 07 33.44	32.32	17,753.07	133 21 46.90		
125	See Horn	78 34 44.38	43.79	9,407.05	31 50 44.29		
126	Hannibal	71 17 45.14	44.31	18,371.82	283 06 15.48	39 41 19.73	91 19 23.48
		02.96	00.42				
125	See Horn	70 10 38.64	38.88	9,407.05	31 50 44.29		
126	Hannibal	73 12 38.24	38.24	14,838.64	138 35 52.93		
127	Heather	36 36 42.73	43.22	15,100.88	281 54 46.04	39 47 20.42	91 26 15.86
		59.61	00.34				
126	Hannibal	27 35 52.47	51.68	14,838.64	138 35 52.93		
127	Heather	96 43 16.73	15.92	8,323.07	221 48 13.34		
128	Marble Head	55 40 53.14	52.71	17,842.85	346 09 50.06	39 50 41.52	91 22 22.50
		02.34	00.31				
127	Heather	72 25 15.78	16.30	8,323.07	221 48 13.34		
128	Marble Head	63 42 10.74	11.48	11,447.78	105 32 54.25		
129	Nelson	43 52 31.48	32.44	10,765.80	329 20 29.26	39 52 20.76	91 30 06.58
		58.00	00.22				
127	Heather	37 22 08.22	08.67	10,765.80	149 22 57.04		
129	Nelson	105 13 17.54	17.59	10,755.90	224 07 11.37		
130	Quincy	37 24 32.91	33.72	17,099.61	6 45 59.99	39 56 31.00	91 24 51.18
		58.67	00.28				
129	Nelson	43 32 53.63	53.35	10,755.90	224 07 11.37		
130	Quincy	103 41 27.95	28.11	13,694.27	147 52 01.82		
131	Lagrange	32 45 38.81	38.90	19,311.85	00 34 23.24	40 02 46.88	91 29 58.45
		00.39	00.36				
130	Quincy	32 14 29.35	28.96	13,694.27	147 52 01.82		
131	Lagrange	119 49 05.49	03.96	15,591.80	207 59 40.38		
132	Lima Lake	27 56 26.82	27.55	25,357.01	00 06 32.09	40 10 13.14	91 24 49.15
		01.66	00.47				
131	Lagrange	43 41 43.43	43.89	15,591.80	207 59 40.38		
132	Lima Lake	38 09 05.75	07.69	10,881.18	66 12 07.33		
133	Canton University	98 09 07.43	08.69	9,730.18	344 16 44.87	40 07 50.57	91 31 49.67
		56.61	00.27				
132	Lima Lake	37 48 27.02	26.92	10,881.18	66 12 07.33		
133	Canton University	60 11 28.45	28.76	6,735.80	185 56 07.42		
134	Cougill	82 00 03.52	04.48	9,534.25	283 56 21.93	40 11 27.78	91 31 20.22
		58.99	00.16				
132	Lima Lake	69 34 55.57	54.98	9,534.25	104 00 34.25		
134	Cougill	74 44 01.99	02.27	15,317.97	209 12 19.66		
135	Gillham	35 41 02.13	03.11	15,768.14	353 34 41.08	40 18 41.16	91 26 03.69
		59.69	00.36				
134	Cougill	22 27 56.66	56.80	15,317.97	209 12 19.66		
135	Gillham	127 07 31.52	32.30	11,564.38	156 28 16.49		
136	Yellow Banks	30 24 30.52	31.26	24,129,02	6 45 40.54	40 24 24.65	91 29 20.13
		58.70	00.36				

Tabulated results of secondary triangulation from Cairo to Keokuk—Continued.

No.	Stations.	Observed angles.	Adjust'd angles.	Distance.	Azimuth.	Latitude.	Longitude.
		° ′ ″	″	*Meters.*	° ′ ″	° ′ ″	° ′ ″
135	Gillham............	44 10 41.79	42.72	11,564.38	156 23 16.49	....	....
136	Yellow Banks.......	82 03 42.90	44.26	9,992.28	58 24 53.54	....	....
137	Fox River..........	53 45 32.14	33.31	14,200.89	292 06 33.13	40 21 34.82	91 35 20.87
		56.83	00.29				
136	Yellow Banks.......	107 55 13.27	14.17	9,992.28	58 24 53.54	....	....
137	Fox River..........	28 09 47.27	48.19	13,707.39	266 30 48.01	....	....
138	Warsaw.............	43 54 56.47	57.80	6,799.60	130 32 01.37	40 22 01.44	91 25 40.96
		57.01	00.16				
136	Yellow Banks.......	46 52 40.38	40.85	6,799.60	310 29 39.37	....	....
138	Warsaw.............	37 44 11.48	12.37	4,985.03	168 16 13.74	....	....
139	Boardman...........	95 23 06.24	06.83	4,180.04	83 38 52.72	40 24 39.68	91 26 23.95
		58.10	00.05				
138	Warsaw.............	35 52 16.26	16.71	4,985.03	168 16 13.74	....	....
139	Boardman...........	77 22 15.74	15.86	3,179.06	270 53 30.04	....	....
140	Hughes.............	66 45 27.24	27.47	5,294.08	24 09 29.96	40 24 38.06	91 24 09.13
		59.24	00.04				
138	Warsaw.............	50 12 55.20	56.15	5,294.08	204 08 30.45	....	....
140	Hughes.............	67 46 52.56	51.80	4,607.46	316 22 38.16	....	....
141	Worster............	62 00 11.21	12.11	5,550.52	74 23 53.38	40 22 49.90	91 21 54.38
		58.97	00.06				
138	Warsaw.............	33 03 35.00	35.09	5,550.52	254 21 26.60	....	....
141	Worster............	85 24 20.38	21.69	3,444.29	159 48 15.07	....	....
142	Keokuk.............	61 32 02.31	03.27	6,293.56	41 19 45.66	40 24 34.70	91 22 44.81
		57.69	00.05				
141	Worster............	32 37 09.55	09.56	3,444.29	159 48 15.07	....	....
142	Keokuk.............	48 13 31.78	31.73	1,880.62	291 34 10.66	....	....
143	Hamilton...........	99 09 18.51	18.72	2,601.80	12 25 40.01	40 24 12.28	91 21 30.64
		59.84	00.01				
142	Keokuk.............	66 28 23.54	24.25	1,880.62	291 34 10.66	....	....
143	Hamilton...........	55 39 35.20	36.28	2,036.22	167 14 35.01	....	....
144	Rapids.............	57 51 58.61	59.48	1,833.75	45 06 22.13	40 25 16.66	91 21 49.71
		57.35	00.01				
143	Hamilton...........	38 21 52.69	52.10	2,036.22	167 14 35.01	....	....
144	Rapids.............	89 15 08.22	08.10	1,595.48	76 29 30.75	....	....
145	Lower Base.........	52 22 60.12	59.81	2,570.40	308 51 47.89	40 25 04.56	91 22 55.52
		01.03	00.01				
144	Rapids.............	35 35 17.56	18.95	1,595.48	76 29 30.75	....	....
145	Lower Base.........	98 42 43.06	44.36	1,297.38	157 46 03.70	....	....
146	Upper Base.........	45 41 54.98	56.69	2,203.60	292 03 53.52	40 25 43.51	91 23 16.34
		55.60	00.00				

APPENDIX C.

REPORTS OF ASSISTANT ENGINEERS J. A. PAIGE, J. B. JOHNSON, AND L. L. WHEELER UPON THE FIELD-WORK AND REDUCTION OF PRECISE LEVELS BETWEEN CARROLLTON, LA., AND BILOXI, MISS., AND BETWEEN CAIRO, ILL., AND FULTON, ILL., EXECUTED UNDER THE ORDERS OF THE MISSISSIPPI RIVER COMMISSION, 1880–'81–'82.

1. *Report of Assistant Engineer J. A. Paige upon the field-work of* 1880–'81, *Grafton to Cairo.*

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., September 21, 1883.

SIR: I have the honor to make the following report of field operations on precise levels on the Mississippi River, between the mouth of the Illinois River and Cairo, from August 10, 1880, to March 16, 1881.

The organization of the party was as follows: James A. Paige, assistant engineer, in charge; O. W. Ferguson, assistant engineer; E. H. Sankee, recorder; H. P. Bourne, recorder; four rodmen, one cook, and eight axmen.

On October 23, Mr. Sankee, by your orders, was transferred another party, and Mr. P. P. Sanborne reported for duty on the same day.

Your verbal instructions previous to my taking the field, were: To quarter the party on the quarter-boat Louisiana, obtain the necessary instruments from the office, purchase subsistence stores, and have the outfit towed to Grafton; establish a bench-mark on the right bank of the Illinois River near its mouth, which should be the beginning of the line; transfer the levels across the Illinois River; carry the work (which would consist of two independent lines of levels) down the left bank of the Mississippi River to the mouth of the Missouri; cross here to the right bank of the Mississippi River, in order that permanent bench-marks might be well established in the edge of the bluffs, which form the right bank mainly from Saint Louis to Commerce; and ultimately connect with the bench-marks in Cairo established by General Comstock's parties in 1876.

On August 10, the quarter-boat was furnished and, by the steamer Little Eagle No. 3, was towed to Grafton. The first field-work consisted of determining the constants of Kern levels Nos. 1 and 2, and the level vials belonging to them. Kern level No. 1 was used by O. W. Ferguson with level vial No. 7 till October 7, when it was broken; after that date level vial No. 3 was used. Kern level No. 2 was used by James A. Paige with level vial No. 2 throughout the season. Redeterminations of the value of the constants were made as follows:

Wire intervals of both levels at Neeley's Landing and at Cairo.

Relative size of rings of level No. 2 at Neeley's Landing and at White Sand Depot Landing.

Value of one division of level vial No. 2 at Neeley's Landing and Cairo.

Value of one division of level vial No. 3 was determined at Illinois station, where it was first used, and again at Neeley's Landing and at Cairo.

In reduction of the field-notes the value of these constants found at any time was used until a new determination was made; after that time the last value found was used.

The weather for the first three months of the field season was very favorable to the work. On the 15th of November cold weather set in, and from that date till February 22 there were only 25¼ days for both parties of field-work done. While at Neeley's Landing December 18, the ice began running so badly that the quarter-boat could be moved no farther. This hindered the work very much. Finally the river was entirely frozen over, and remained so till February 3, when a cake of ice extending entirely across the river struck the quarter-boat and sunk her. With the aid of a derrick and some other appliances obtained at Grand Tower the boat was raised and repaired, and on February 22 moved to Commerce, Mo., to which point Assistant Ferguson had carried the levels.

The work was completed to Cairo on March 14, the quarter-boat towed to Mound City and turned over to watchman Schoenfeld, and with Mr. Ferguson I reported to you for further duty at Saint Louis.

The general conditions regarding the work during the latter part of the season were unfavorable. Low water prevailed nearly the entire season. To move the quarter-boat by drifting with the current very often resulted in being hung up on a rock or blown on a sand bar. The boat lay at Neeley's Landing nine weeks. Part of the force remained to look after the boat, while Assistant Ferguson continued the work below whenever the weather would permit, subsisting at farm houses.

During this time and for some time previous the ground was frozen, and, as has been found previously, when running over such a surface, it is impossible to keep the level stationary. Also, part of the line was through wheat fields and swampy woods. About 22 per cent. of the whole distance was leveled more than twice, and one per cent. was leveled more than three times.

The whole number of days and parts of days spent in field-work equals 220 days for one party. The whole number of kilometers leveled equals 797.5. Average rate per working day equals 3.6 kilometers.

There were 66 permanent bench-marks established. Eleven of these were of the usual pattern—stone posts in ground with copper bolt in top. The remainder, with one exception, were copper bolts one centimeter in diameter and 7 centimeters long, leaded in brick or stone foundations, or in the natural rock wall. Those of the latter locality, if not interfered with, are as permanent as anything of this nature can be established. Where the copper bolts were set horizontally a small hole in the end of the bolt marks the point of reference. Temporary bench-marks were set about once in every kilometer.

While in the field, a descriptive list of bench-marks was received, established in 1879, by surveys made under direction of Colonel Simpson, Corps of Engineers, between Carondelet and Kaskaskia, with directions that they be connected with. Thirty-three of these sixty-four bench-marks were found and connected with. They are designated in the field-notes and office computations as "B. M.—Holman."

There were six water-gauges connected with the levels, viz: at Grafton, Saint Louis, Rush Tower, Grand Eddy, Gray's Point, and Cairo. At all of these gauges except the Gray's Point gauge, there was a permanent bench-mark left in the immediate vicinity.

The methods used in field-work were, with a few exceptions, the same as have been used heretofore, and need not be further described, any changes made being incidental to the locality, state of the weather, &c.

There were 4 river crossings made by reciprocal leveling—one at the beginning of the work across the Illinois River, one at the mouth of the Missouri, one at Chester, and one at Commerce. When these crossings were made, a copy of the field-notes and computations was forwarded to you.

Very respectfully, your obedient servant,

JAMES A. PAIGE,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

2. *Reports of J. B. Johnson upon the field-work of* 1882-'83, *Carrollton to Biloxi, and Grafton to Chicago.*

a.—CARROLLTON TO BILOXI.

NEW ORLEANS, LA., *June* 26, 1882.

SIR: I have the honor to report upon the field-work of the precise level party under my charge, in connecting the United States bench-marks at Carrollton, La., with the tide-gauge at Biloxi, Miss.

The party consisted of J. B. Johnson, assistant engineer in charge; O. W. Ferguson, assistant engineer; A. Ramel, recorder; A. E. Kastl, recorder, together with four rodmen and five laborers.

I left Saint Louis May 3, reaching New Orleans on the 5th. A reconnaissance was made on that day, and a line agreed upon for reaching the Mobile and New Orleans railroad by running back of the city. On the 6th instrumental constants were observed, and on Monday, May 8, the regular work commenced.

On the 9th I left the party for five days, under orders to visit the observation party at Red River Landing. Recorder Ramel observed with my instrument while I was on this trip, as well as on all other occasions when it was necessary for me to be absent from the work. The work was completed at Biloxi tide-gauge June 23. Instrumental constants were observed on the 24th, and the party returned to New Orleans on the 26th. A connection was then made with the New Orleans City datum, which could not be found when the work was in that vicinity.

The party was disbanded June 27. Mr. Ferguson taking part of the outfit to Columbus, Ky., and the remainder shipped to Saint Louis by Anchor Line steamers.

DESCRIPTION OF THE LINE.

The total length of the line from Carrollton to the Biloxi gauge is 139 kilometers = 87 miles. Of this, 18 kilometers was on wagon roads, 50 kilometers on railroad through swamp, 7 kilometers on railroad bridges and trestles, 64 kilometers on railroad over dry sandy land.

The characteristics of the swamp region were learned from the road master. He says there is a solid sand bottom from 2 to 15 feet below the surface throughout the whole distance. A vegetable growth and mold has formed on the surface, which extends some 2 or 3 feet down. If the sand substratum is deeper than this, the intermediate region is filled with a soft liquid mass which offers no resistance whatever. The road-bed was first made by dredging a canal alongside the line, and depositing the mud on the line. Sand was then brought in scows, on this side canal and put on top of the mud road-bed, until it was stable enough to lay a track.

For several years after the track was laid the road-bed rapidly settled away in places and more sand was constantly hauled to raise it again. Lines of piles were driven in many places between the track and the side canal, to prevent the road-bed from flowing back into the canal. These piles are all driven into the solid sand bottom, however, and are very firm. The road-bed now seems to be quite stable, and I think the fill has sunk down to the solid substratum and there will be little more settling away. All the piling under the bridges and trestles are driven in sand. Our lines checked quite as well through the swamp region as on the solid ground. The road-bed for the entire distance, is composed of sand, which makes an excellent basis for foot plates and instruments as it is non-elastic. The 7 kilometers on bridges and trestles were distributed as follows:

	Meters.
Chef Menteur-Bridge	560
Rigolets Bridge	1,100
Pearl River Bridge	520
Bay Saint Louis trestle	3,700
Biloxi Bay to gauge trestle	1,120
Total kilometers	7.000

The bridges were double quadrangular iron truss bridges of 100 feet span, resting on piers made up of sixteen piles each. These piles were well capped and held at top, and also by diagonal tie-iron rods, reaching from top to bottom of piers. The trestle-work rested on piers every fifteen feet, of six piles each. The water was not over 20 feet deep on any of these crossings, except that of the Rigolets, which was as much as 48.

The Chef Menteur, Rigolets, and Pearl River are outlets from Lake Pontchartrain into Lake Borgne, and are subject to strong currents as the tide ebbs and flows, or the wind drives the water in or out. All these bridges and trestles were found very solid, and furnished a good basis for the instruments when there was little wind and current, otherwise work could not be done on them. These were all crossed four times under favorable circumstances, except Pearl River bridge, which was crossed but three times. All these lines agreed as closely as on any other part of the work.

METHODS OF WORK.

The methods employed were, in the main, the same as those heretofore used with the Kern instruments and rods. The two lines were always run in opposite directions, Mr. Ferguson always running west, and I always running east.

In one particular the methods of making the observations have differed from those previously used, and that is *the bubble was always kept in the middle of the tube when taking a reading*

This method was not adopted arbitrarily or rashly. In my first season's work I found that my bubble changed its value from 2.6 to 3.5 seconds, according to temperature. I therefore kept my bubble corrections *very small* so as not to introduce any large uncertainty from that source. In the first half of last season I followed the same plan, and with many readings would have no bubble correction at all. In the latter half of that season's work I kept the bubble exactly in the middle for almost all readings, and found it could be done as well as not. This, of course, presumes that the observer reads his own bubble, a thing which I have always done. Last season Mr. Ferguson had his recorder read his bubble and so could not pursue this method.

A discussion of these two systems is important.

(I.) Having the recorder read the bubble has some advantages, *provided the bubble will stand*. He then can wait till it settles, inform the observer of the fact, and he can read the bubble *in its true position while* the observer reads the rod.

The objections to this are:

(*a*.) It is desirable to have as few men about the instrument as possible. If the recorder reads the bubble there are three men, observer, recorder, and umbrella man, standing directly beside the instrument.

(*b*.) I find that my bubble will seldom stand long enough for me to read the three wires; a single bubble reading is, in this case, certainly erroneous.

(II.) The advantages of the other system are, that it enables the observer to make the complete observation, and also to get all three wire readings with the bubble in one position.

To have one man read the bubble and another to take the shot is like having one to sight a gun and another to pull the trigger, a very good plan with a *fixed gun*, but a very poor plan when the gun is somewhat unsteady and controlled by the man who pulls the trigger. When the bubble is almost constantly in motion, the same man must see both bubble and wires, and at the same time, and keep them both in view, in order that he may know when the bubble is registering correctly. By holding the head to one side the observer can keep his left eye on the bubble and his right eye on the rod, and see the bubble super-imposed on the rod; or, if he finds it difficult to read with both eyes at once, he can see bubble and rod alternately without moving his head and only by opening and closing his left eye. Now with his hand at the elevating screw, under the eye end wye, he brings the bubble to the center and keeps it there, stopping to look at the bubble for each wire reading.

After having read one wire, if the bubble has run, bring it back, read the next wire, again examine the bubble, bring it to the center again, and read the third wire.

Let him do the same also for the second set of readings (for the wires should all be read twice), and then, having kept the bubble in the same place, he can confidently assert the reliability of his work. With 100-meter shots, if the bubble is read one-half division wrong, an error of $0^{mm}.6$ has been made.

The bubble often *seems* to have stopped moving when one-half to three-quarters division from its true point of equilibrium, and therefore the second set of wire readings will often differ from the first.

It may be said it requires too much time to bring the bubble exactly in the middle, but I think it requires no more time than to bring it to any other point, for it must be watched and kept to one reading anyway, if good work is to be done, and it might as well be kept in the middle as anywhere else.

I have run 1¼ miles per hour by this method of work, on 100-meter shots, and I do not find it at all difficult to make ten settings an hour of 80-meter shots, making a mile an hour on 80-meter shots. This got to be about our normal gait.

Another objection that is made to the observer's reading his own bubble, is that he cannot read it correctly, there being a parallax of about one-half division at each end, caused by the light passing obliquely from the bubble to the mirror, in order to reach the eye.

The instructions say that the eye must be held in such a position that there will be no parallax. This cannot be done. The objection, however, has little force, provided the back and fore sights are kept equal. The error being always constant and effecting back and fore sights alike, their difference is not changed, and if the back and fore sights are very unequal, this one-half division error in bubble reading can be applied, together with the corrections for collimation, inclination, and pivots. In fact, it and the pivot error being sensibly constant, may be combined, and their resultant used in connection with collimation and inclination errors. For these reasons I determined on having no bubble corrections in my work for this season, and Mr. Ferguson, with some reluctance, adopted the same method. I think our extraordinary close agreements amply justifies the scheme.

I believe that, when the conditions are favorable, this matter of the bubble readings is the chief source of error. If the saving of time in the computations may be allowed as an argument, this method has a great advantage over the old one.

Our field work has all been reduced in two note-books, instead of on the computation sheets, with a saving of three-quarters of the time it formerly required for this work. This certainly reduces the cost of the field work, for that now never has to be stopped to work up notes. I therefore conclude that the method is more accurate, less laborious, and cheaper than that formerly used. The value of the bubble also, and the changes in the same, become of no consequence, neither is an accurate value of the wire interval of much account, except as getting the distance run.

In all other respects the methods employed have been the same as those used before. The permanent bench-mark stones have generally been set on side lines, so that any settling that may have occurred in them has not affected the accuracy of the line.

Twenty-two permanent bench-marks have been set, twelve of which are stones set in the ground, east of Pearl River, and the rest are copper bolts leaded into draw-piers, abutments, brick buildings, &c. Superintendent J. T. Harahan very kindly gave us the use of a hand-car, which was of great service and materially facilitated the work. No other favors were asked or received from the railroad company, and in return for this one, I have prepared a list of our permanent bench-marks with their elevations, and also the elevations of the road-bed at every station, which will amply repay them for the use of the car.

Most of the work has been done from 6 to 8 a. m. and from 4 to 7 p. m. There have been very few days when work could be done between 8 a. m. and 4 p. m.

The party were quartered at but six places between New Orleans and Biloxi, a distance of 80 miles, three of these being club-houses for New Orleans hunters and fishermen.

RESULTS.

The length of line was 139 kilometers (87 miles). This was run in forty-seven days, May 8 to June 23, inclusive. Seven kilometers of this distance (4.4 miles) was required to be run four times. This gives 91.4 miles of duplicate line completed in forty-seven days, 1.9 miles per day. The full party was under pay fifty-one days. Field-work was done on thirty-six days, making an average of 2.6 miles per day for every day on which work was done. Of the remaining fifteen days nine were Sundays, four were rainy, one was windy, with the tents inaccessible, and one day was spent in connecting with a stone and setting a water-gauge at "West End" on Lake Pontchartrain.

DISCUSSION OF RESULTS.

There were five discrepancies in the season's work beyond the limits; four of these were errors of 10 millimeters, and one of 20 millimeters. It is pretty well determined that these all occurred by allowing the rods to get out of the sockets in the foot-plates.

These sockets are just 10 millimeters in depth; every time a train passes the rod is taken out, and in replacing it the rodman is very careful not to jar the plate. Neither should he incline the rod too much in putting it back for fear of bringing a lateral pressure on the plate and so moving it. He therefore cannot get down to look at it, neither can he let it in so as to hear the click as it drops into the socket, as he can when he first sets up, so that some of those errors may have come in from this cause.

Another cause would be the strong wind, in which we were often able to work on account of the protection afforded the instruments by the tents. The rods, however, had no protection, and it was with the greatest difficulty that the rodmen managed to keep their rods in place. They used a stick to brace up the rod on the leeward side, and if this was held firmly against the rod, the wind against the top, would tend to lift the rod bodily out of the socket. One of the rods was found in this condition one day, the spur resting out on the top of the plate, and it had evidently been done in this way, the rodman not being conscious of the change.

Aside from these five errors, which determinations were rejected in the field computation, there were no discrepancies beyond the limit on the entire line.

A number of stretches were run a third and fourth time to reduce the probable error, although already within the limit, all determinations being used.

There was no marked divergence in the plot of the two lines until the last two weeks. This, I think, was caused by the road-bed becoming very dry, there having been no rain in that time. When trains pass, the whole road-bed is shaken somewhat, and if there is dry sand about the foot-plates it is liable to work under them, and so raise them slightly. The discrepancies are in the direction to indicate a raising of the foot-plates. The results obtained on the bridges and trestles are very satisfactory.

We have for the five such stretches:

Locality.	Distance.	Number of lines.	Maximum discrepancy.	Probable error of mean.
	m.		*mm.*	*mm.*
Chef Menteur	560	4	1.3	0.2
Rigolets	1,100	4	1.3	0.2
Pearl River	520	3	0.9	0.2
Bay Saint Louis	3,700	4	3.5	0.5
Biloxi Bridge	1,120	4	3.5	0.5

Many trains passed, both while crossing these bridges and also between the different crossings. The evidence is conclusive that there is no appreciable settling of these piles for passing trains. The probable error in the mean for the entire line is 7 millimeters. This corresponds to a probable error in the mean of 0.60 millimeters per kilometer, a degree of accuracy not hitherto attained, I believe, in this country.

It will be seen, by comparing their elevations in the summary, that the 6-foot mark on the Biloxi gauge is 25.5 millimeters below the zero of the Carrollton gauge. The keeper thinks mean tide is a little below the 6-foot mark. It is likely, therefore, that the zero of the Carrollton gauge will prove to be some 2 or 3 inches above mean tide.

The work is much indebted to the attention paid to it by Major Harrod. It was through his influence that a hand-car was obtained, and also that the party was allowed to occupy various club-houses through the swamp region. The organization of the party was very satisfactory. Mr. Ferguson is always to be commended for the intelligence, care, and conscientious devotion he brings to the work, and Recorders Ramel and Kastl are well deserving of further employment. Mr. Ramel acted as an observer on 31 stretches, aggregating 24 miles, on only one of which was the discrepancy beyond the limit, and that one by 10 millimeters, probably an error of the rodman

Very respectfully, your obedient servant,

J. B. JOHNSON,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Corps of Engineers, U. S. A., Secretary Mississippi River Commission.

b.—GRAFTON TO CHICAGO.

SAINT LOUIS, *September* 1, 1883.

SIR: I have the honor to submit the following report of the field work of precise levels from Grafton to Chicago. This work was done in three seasons, viz:

I. Grafton to Keokuk, 151 miles, done May 21 to August 30, 1881.
II. Keokuk to Fulton, 170 miles, done September 6 to November 25, 1882.
III. Fulton to Chicago, 170 miles, done May 2 to August 7, 1883.

The observers for all this work were O. W. Ferguson and J. B. Johnson. Each observer had a recorder, two rodmen, and two axmen at his disposal, thus making two separate working field parties. Both parties were quartered together, and were in charge of J. B. Johnson. From Grafton to Keokuk they lived on a quarter-boat; from Keokuk to Chicago they found accommodations in the villages, and used a hand-car to go to and from work. Of the 491 miles of line from Grafton to Chicago, 406 miles were run on railroads, and 85 miles along the edge of the river bank. From Grafton to Savanna, the most northerly point reached on the river, railroads were only used when they were in close proximity to the river bank.

BENCH-MARKS.

From Grafton to Chicago 147 permanent bench-marks were set, 110 of which may be found near to the river, between Grafton and Savanna; of the remaining 37, 31 are on the line of the Chicago, Milwaukee and Saint Paul Railway, from Savanna to Chicago, and 6 in the city of Chicago. These bench-marks are nearly all copper bolts leaded into natural rock, bridge piers, and abutments, foundations of buildings, and in stones set in the ground. They are generally marked with the letters
US
⊙
PBM
arranged in this manner about the bolt-head. Most of them are set horizontally in vertical walls and faces of rock, and the balance vertically in horizontal surfaces. The latter are more convenient to connect with, but are more liable to be disturbed and covered from sight.

In addition to these permanent benches, connection was made with 30 "permanent bench-marks" set in Colonel Farquhar's survey of the Mississippi River, and published in the Report of Chief of Engineers for 1880, page 1520.

Temporary bench-marks were set about every kilometer, or whenever the work was interrupted. There were usually points of natural rock, abutments, spikes in stumps or roots of trees, or in the trestle-work over piles, or else stakes driven in the ground. Where the stability of the temporary bench was not assured, more than one was set; in this case, both were connected with again in starting from them, and the mean elevation of the two was used in continuing the line. With but one exception, no temporary bench was ever found to have moved, and this one was a spike in a cattle-guard where the timbers were afterwards found to be decayed. This movement was discovered in the field, and the line continued from the next set of benches back on the line.

LOCATION OF LINE.

The location of the line run is as follows:

From Grafton to Clarksville, 58 miles, on the east bank of the river.

From Clarksville to Burlington, 135 miles, on the line of Saint Louis and Keokuk, and Chicago, Burlington and Quincy railways, on the west bank.

From Burlington to New Boston, 36 miles, on the line of the Chicago, Burlington and Quincy Railway, on the east bank.

From New Boston to Port Louisa, 9 miles, on the east bank, through the bottoms.

From Port Louisa to Muscatine, 18 miles, on the west bank, through the bottoms.

From Muscatine to Rock Island, 29 miles, on the line of the Chicago, Rock Island and Pacific Railway, on the west bank.

From Rock Island to Savanna, 58 miles, on the line of the Chicago, Milwaukee and Saint Paul Railway, on the east bank.

From Savanna to Chicago, 148 miles, on the line of the Chicago, Milwaukee and Saint Paul Railway.

This necessitated crossing the river four times with the line of levels, viz, at Clarksville, Burlington, Port Louisa, and Rock Island.

At Clarksville and Port Louisa the crossings were effected by simultaneous readings with two instruments on opposite sides of the river, the midwire bisecting a large target on the opposite shore. Sixteen readings were taken by each instrument, in sets of four, which were as follows:

1. Telescope normal, level direct.
2. Telescope normal, level reversed.
3. Telescope inverted, level direct.
4. Telescope inverted, level reversed.

Then each observer, with his instrument, crossed over, and the same was repeated.

The longest readings thus taken were about 600 meters. Very good results were obtained, the probable error being less than a millimeter.

At Burlington and Rock Island the crossings were made on bridges.

INSTRUMENTS.

The instruments used on this work are the Kern levels, and rods similar to those used in the precise levels of Switzerland, and are made by J. Kern, of Aarau. The instrument, with tripod, weighs 22 pounds. It has three steel leveling screws, with enlarged spherical ends at bottom, which are held to the tripod head by clamps fitting over the spherical enlargements. The wye adjustment is by means of a thumbscrew of very fine thread, so that the last final centering of the bubble is made with this screw. The bubble tube is fixed in a striding wooden case, with brass ends fitting on the collars of the telescope. The bubble case has a glass cover and a mirror that may be raised to the angle of 45° and so reflect the bubble image to the eye of the observer at the eye-piece. The telescope clamps also hold the bubble case in position; this is removed, however, when the instrument is carried. The telescope gives an inverted image. The reticule has three horizontal wires, all of which are read, and the mean taken as the reading of that sight. This also gives a stadia measurement of the distance.

The rods are 3 meters long, made of two pine boards with a T-shaped cross section, provided with an iron spur at bottom with a flat end, and a watch level by which to hold it vertical. They are graduated to centimeters, and are read by estimation to millimeters. No target is used.

FIELD METHODS.

1. *Duplication.*—In all this work the lines between benches have always been duplicated by running the second line in the opposite direction. From Grafton to Keokuk the duplicate lines were run by different observers, Mr. Ferguson always running north and Mr. Johnson south. From Keokuk to Chicago each observer duplicated his own work. It was never attempted to carry two lines simultaneously with one instrument.

2. *Observation.*—Great care was taken to always get the back and fore sights equal in length. Since the interval between extreme wire readings gave a stadia measurement of the distance, the recorder knew, by means of the continued sum of back and fore sight intervals, at all times, what the total difference was, and could instruct the rodman to make the requisite correction. This was carefully attended to.

The bubble was always read by the observer in the mirror set for that purpose. This was read by the observer's left eye, without removing his right eye from the eye piece. There was a small parallax on the bubble when the eye was in this position, but since the error was constant for both back and fore sights, it was eliminated. From Grafton to Keokuk the bubble was brought approximately to the middle and read, and a correction applied for its eccentric position. From Keokuk to Chicago, the bubble was brought carefully to the center and held there by means of the very delicate wye adjusting screw, so that there were no corrections for bubble displacement on this part of the work. The latter method was found to be about as convenient in the field, and it saves much work in reduction.

In connecting with horizontal benches it was the common practice to set the instrument on a plane with the bench and make the middle wire bisect the small hole in the center of the bolt, reading both back sight on rod and fore sight on bolt, with the telescope in both normal and inverted positions. This was necessary, because three wires were read on the rod, and the middle wire did not exactly coincide with the mean of the three.

The rod supports used in 1881 and 1883 were iron foot-plates of some 18 square inches area, triangular in shape, having a handle, 3 spurs at bottom, and a socket in the top, with a convex bottom to receive the spur of the rod. In 1882 iron pins were used in addition to the foot-plates, or, in place of them, on portions of the line where, from our experience, they were thought to be better than the plates. This was on alluvial, moist, or springy ground, where the plates were liable to change their elevation. Sometimes in the woods it would be almost impossible to get good solid earth on which to set the plate. The pins were found to work very well in these places, but in loose earth, as sand or unpacked gravel, the foot-plates are greatly superior. If but one kind of support is to be used under all conditions, the foot-plates are preferable.

INSTRUMENTAL CONSTANTS AND ADJUSTMENTS.

The value of one division of the level bubble in seconds of arc was determined two or three times each field season, also the difference in the diameters of the telescope collars, and the correction therefor, and the value of the wire intervals. The adjustment of the bubble tube, and the line of collimation of the mean of the three wires, to the axis of the telescope collars, was made or examined every time the instruments were set up, and again on closing a stretch. In the former case the error of parallelism was made very small, and in the latter its absolute value, in seconds of arc, was found by reversed readings. These values, found at the close of the stretch, called corrections for "inclination" and "collimation," together with the correction for inequality of collars, called the "pivot" correction, were all evaluated for the residual difference in distance between sums of back and fore sights, and the resulting correction applied to the computed elevation of the forward benches. The algebraic sums of these corrections seldom amounted to more than one or two-tenths of a millimeter, on account of the care taken to keep the back and fore sights equal.

The corrections resulting from the condition of the instrument at the close of the stretch were alone used, because where constant care had been exercised to keep the back and fore sights balanced up, the residual difference would usually be made on the last one or two settings.

PROGRESS.

The following table shows the rates of progress made in the three seasons:

Item.	Grafton to Keokuk.	Keokuk to Fulton.	Fulton to Chicago.	Grafton to Chicago.
Length of line	151	170	170	491
Number of days in entire field season	94	81	98	273
Number of days in which work was done	73	58	67	198
Average daily run in miles for entire season	1.6	2.1	1.7	1.8
Average daily run in miles for working days	2.1	2.9	2.5	2.5

These average runs may be taken as finished duplicate work by the two parties or as single line by one party.

The greater progress made in the season of 1882 was due to the good weather and the use of the hand-car and the observing tents. These latter were made to be used on the Gulf coast to protect the instrument from the wind. They are 5 by 6 feet wall-tents, with one 8-foot center pole, held at bottom by eight steel pins. They allowed work to be done on many days when it would have been impossible without them.

CONNECTIONS AT CHICAGO.

The object of carrying the line to Chicago was to connect with Lake Michigan. The Lake Survey had determined the elevation of certain bench-marks at Milwaukee, as well as the mean elevation of Lake Michigan, for the months of May, June, July, and August, 1875, and also the mean elevation of the lake from January 1, 1860, to December 31, 1875, above mean sea-level at New York City.

At Chicago a gauge had been read three times a day at the crib, being the entrance to the tunnel two miles from shore, since 1872. This gauge had apparently remained undisturbed since it was first set. Its zero was set at 8.01 feet above city directrix by spirit levels carried through the tunnel. In 1878 a water-level connection of great accuracy was made by the present city engineer, Mr. S. G. Artingstall, between the crib and the shore, and the crib gauge was found to be 0.246 foot too low by the shore benches. The crib gauge was taken as correct, however, and corrections applied to the shore bench-marks. By this decision the city directrix is a point 8.01 feet below the zero of the crib gauge.

The line of precise levels was joined with eight city benches and with the crib gauge by water levels. These water levels consisted in reading 3 gauges on shore and 2 at the crib every five minutes for seven consecutive hours on a calm day. This connection from shore to crib agreed with that of the city engineer in 1878 to the nearest thousandth of a foot.

Having thus joined the line of precise levels with the zero of the crib gauge, it remained only to obtain a comparison of gauge-readings at Chicago and Milwaukee to transfer the Milwaukee elevations to Chicago. Thus the Mississippi River line of precise levels is joined to the United States Lake Survey line of levels from New York City. (For a description of the determination of the elevation of the Great Lakes, see Professional Papers, Corps of Engineers, No. 24, p. 595.)

The following recorders have assisted on the work: A. Ramel, P. P. Sanborn, A. L. Arner, E. K. Woodward, jr., and S. J. Fitzhugh, all of whom discharged their duties with credit. My assistant, Mr. O. W. Ferguson, deserves especial mention for the accuracy and rapidity with which he has always done his work.

Very respectfully, your obedient servant,

J. B. JOHNSON,
United States Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

3. *Report on reduction of precise levels, by L. L. Wheeler, assistant engineer.*

COTTONWOOD POINT, MO.,
October 29, 1883.

SIR: I have the honor to submit the following report upon the reduction of precise levels, made under my direction. These levels include the following sections: From Carrollton, La., to Biloxi, Miss., a distance of 140 kilometers; from Grafton, Ill., to Cairo, Ill., a distance of 346 kilometers; from Keokuk, Iowa, to Grafton, Ill., a distance of 242 kilometers; and from Keokuk, Iowa, to Fulton, Ill., a distance of 267 kilometers.

In the reductions made under my direction, the greatest care has been taken that no errors of computation should enter into the results. All reductions have been checked, either by comparison with the corrected field reduction, or by two persons computing the same results independently. It is therefore believed that the results here given may safely be taken as the correct ones resulting from the observations.

In these four sections the instruments used were alike, and the method of field work nearly the same throughout.

The instruments and rods were manufactured by J. Kern, of Aarau, Switzerland, and are similar to those described in the Report of the Chief of Engineers for 1877, page 1190.

Table A shows the various determinations of the instrumental constants up to the date of the completion of the line from Keokuk to Fulton.

Table B shows the instrumental constants used in reducing the notes of each section, and the computers' names. In this table *i* and *i′* are the angular distances of the upper and lower wires, respectively, from the midwire, and I is the angular distance between extreme wires. The remainder of the table is sufficiently explained by the headings of the columns.

TABLE A.—*Constants for Kern levels and Kern level rods.*

[*p* is for "pivot correction," or correction for inequality of telescope rings. It is the angular correction to be applied to the line of collimation to reduce it to the horizontal plane of the upper surface of the rings. *v* is the value of one division of the level tube in seconds of arc. L is the length of a three-meter rod.]

Number of instrument.	Constant.	Date.	No. of observations.	Probable error.	Remarks.
	″			′	
Kern level..............1	*p* = — 0.34	Aug. 14, 1880	42	± 0.30	
1	*p* = — 1.04	May 24, 1881	10	± 0.18	
1	*p* = — 1.50	Aug. 11, 1881	10	± 0.05	
1	*p* = — 2.66	Aug. 27, 1881	10	± 0.06	
1	*p* = — 1.38	Feb. 3, 1882	7	± 0.09	
1	*p* = — 3.52	May 11, 1882	14	....	
1	*p* = — 1.91	June 24, 1882	10	± 0.06	
1	*p* = — 2.46	Dec. 20, 1882	8	± 0.13	
2	*p* = + 0.99	Aug. 16, 1880	4	± 0.03	
2	*p* = + 0.50	Oct. 22, 1880	8	± 0.07	
2	*p* = + 1.84	Jan. 8, 1881	16	± 0.02	
3	*p* = + 2.53	May 26, 1881	8	± 0.03	
3	*p* = + 0.17	Feb. 4, 1882	5	± 0.11	
3	*p* = + 0.19	May 11, 1882	14	....	
3	*p* = + 1.10	June 24, 1882	10	± 0.06	
3	*p* = + 2.71	Sept. 6, 1882	6	....	
3	*p* = — 0.37	Dec. 21, 1882	8	± 0.10	
5	*p* = — 1.85	Feb. 4, 1882	5	± 0.05	
Kern level tube........2	*v* = 4.08	Aug. 14, 1880	74	....	
2	*v* = 3.83	Aug. 16, 1880	33	....	
2	*v* = 4.49	Aug. 19, 1880	37	....	
2	*v* = 5.60	Jan. 8, 1881	23	....	
2	*v* = 4.61	Mar. 15, 1881	31	....	
3	*v* = 3.06	Oct. 7, 1880	24	....	
3	*v* = 3.25	Oct. 9, 1880	28	....	
3	*v* = 3.27	Jan. 7, 1881	32	....	
3	*v* = 3.22	Oct. 14, 1881	30	....	
3	*v* = 2.90	May 24, 1881	10	± 0.04	
3	*v* = 3.24	Aug. 9, 1881	10	± 0.02	
3	*v* = 3.04	Aug. 27 1881	10	± 0.03	
3	*v* = 3.21	May 6, 1882	6	....	
3	*v* = 3.19	June 23, 1882	12	....	
5	*v* = 2.94	May 25, 1881	6	± 0.02	
5	*v* = 2.85	Aug. 9, 1881	36	± 0.01	
5	*v* = 2.76	Aug. 27, 1881	10	± 0.03	
5	*v* = 2.86	May 7, 1882	6	....	
7	*v* = 4.25	Aug. 13, 1880	80	....	
11	*v* = 2.66	Aug. 21, 1880	19	....	

TABLE A.—*Constants for Kern levels and Kern level rods*—Continued.

Number of instrument.	Constant.	Date.	No. of observations.	Probable error.	Remarks.
	mm.			″	
Kern leveling-rod.....X	L= 3. 000011	June, 1880 Aug., 1882	....	....	Mean of Lake-Survey determinations, and those in office of Mississippi River Commission.
X	L= 3. 000280	Aug.,1882	....	....	
XI	L= 3. 000102	June, 1880 Aug.,1882	....	....	Mean of Lake-Survey determinations, and those in office of Mississippi River Commission.
XI	L= 3. 000303	Aug.,1882	....	....	
XII	L= 2. 999919	June, 1880 Aug.,1882	....	....	Mean of Lake-Survey determinations, and those in office of Mississippi River Commission.
XII	L= 3. 000113	Aug.,1880	....	....	
XIII	L= 3. 000070	June, 1880 Aug., 1882	....	....	Mean of Lake-Survey determinations, and those in office of Mississippi River Commission.
XIII	L= 3. 000293	Aug.,1882	....	....	
XIV	L= 3. 000029	Aug.,1882	....	....	
XV	L= 3. 000150	Aug.,1882	....	....	
XVI	L= 3. 000032	Aug.,1882	....	....	
XVII	L= 3. 000133	Aug.,1882	....	....	

TABLE B.

	Number of instrument.	Constants of instruments.						Rods.	Mean value of one meter.	Computers.	Remarks.
		p	i	i′	I	Bubble tube.	v				
		″	′ ″	′ ″	′ ″		″		m.		
Carrollton to Biloxi....	Kern level 1	−2.72	17 24.21	17 27.04	34 51.25	No. 3..	3.20	X XII XIV XV	1.000048	L. L. Wheeler.........	New lower horizontal wire put in No. 3 June 1, 1882.
	Kern level 3	+0.64	17 13.90	17 23.95	34 37.85	No. 5..	2.86		....	Alex. E. Kastl	
	Kern level 3	....	17 18.74	17 24.10	34 42.84	....	......	....			
Grafton to Cairo.......	Kern level 1	−0.34	17 23.90	17 24.31	34 48.21	No. 2..	4.50	X XI XII XIII	1.000009	L. L. Wheeler.........	New vertical wire put in No. 3 August 20, 1880.
	Kern level 2	+1.35	17 31.73	17 29.56	35 01.29	No. 3..	3.21		....	O. H. Ferguson	
	Kern level 2	....	17 31.32	17 30.50	35 01.82	No. 7..	4.25	....	....	Alex. E. Kastl	
Keokuk to Grafton	Kern level 1	−1.73	17 23.86	17 20.60	34 44.46	No. 3..	3.06	X XII XIV XV	1.000010	J. B. Johnson	
	Kern level 3	+1.35	17 15.10	17 23.69	34 38.79	No. 5..	2.85		....	O. W. Ferguson.......	
	Kern level 5	−1.85	17 42.98	17 28.64	35 11.62	....	......	....	....	Alex. E. Kastl .... L. L. Wheeler	
Fulton to Keokuk	Kern level 1	−2.46	14 15.99	14 02.88	28 18.87	No. 3..	3.20	XIV XV XVI XVII	1.000029	L. L. Wheeler.........	New wires put in No. 2 August, 1882.
	Kern level 3	+1.17	17 13.90	17 23.95	34 37.85	No. 5..	2.86		....	Alex. E. Karal	
										T. C. Thomas	

Accompanying this report are tables of results and descriptions of the permanent bench-marks.

In the tables of results column 1 gives the bench-mark, T. B. M., signifying temporary bench-mark, and U. S. P. B. M., signifying United States permanent bench-mark.

Column 2 contains the distances in kilometers from the initial bench-mark.

Column 3 gives the direction in which the line was leveled.

Column 4 gives the successive differences of elevation in meters between bench-marks, and the mean of such determinations.

Column 5 gives the residuals found by subtracting each determination from the mean.

Column 6 gives the probable error, r, of the mean in column 4, computed by the formula

$$r = \pm 0.6745 \sqrt{\frac{[vv]}{m(m-1)}}$$

Column 7 gives the probable error R, of the mean elevation of each permanent bench-mark as computed from the beginning of the section.

Column 8 gives the elevations of all bench-marks referred to the Cairo datum plane, which is 290.84 feet below the zero of the United States Engineers' gauge at Cairo, Ill.

Column 9 gives the corrections which are to be applied to the elevations in column 8 to reduce them to standard meters.

Column 10 gives the corrected elevations referred to the same datum plane.

Column 11 gives the initial of the observer for each determination.

"J" is for Assistant J. B. Johnson.
"F" is for Assistant O. W. Ferguson.
"P" is for Assistant J. A. Paige.
"S" is for Recorder E. H. Sankee.
"B" is for Recorder H. P. Bourne.
"Sn" is for Recorder P. P. Sanborn.
"R" is for Recorder A. Ramel.

Column 12 indicates the nature of the support.

The above report is respectfully submitted.

L. L. WHEELER,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

Results of precise leveling.

CARROLLTON, LA., TO BILOXI, MISS.

[Bench-marks marked with an asterisk are not in main line of levels.]

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
C. and G. S. 1, Carrollton.	......	......	......	......	......	......	......	......	†9.0272	
*B. M. Hampson. (Re-established by Maj. Howell)	......	......	−0.3732	+1.1	0.7	......	8.6551	......	......	F.
			−0.3710	−1.1	......	......	......	......	......	F.
		Mean..	−0.3721							
*B. M. Hampson (Williams).	......	......	−0.1980	......	......	......	8.8292	......	......	F.
*B. M. 3, Ripley...	......	......	+0.7479	+0.1	0.1	......	9.7752	......	......	F.
			+0.7483	−0.3	......	......	......	......	......	F.
			+0.7477	+0.3	......	......	......	......	......	J.
		Mean..	+0.7480							

†P. B. M. 1, Carrollton, below P. B. M. 1, Greenville −37.0619 M, furnished in manuscript by the United States Coast and Geodetic Survey. Office Report, 641, A. C. P. B. M. 1, Greenville above Cairo datum 46.0891 M. Report for 1882, page 74.

Results of precise leveling—Continued.

CARROLLTON, LA., TO BILOXI, MISS.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
*B. M. 4, Ripley			+0.4809	+1.0	0.4		9.5181			F.
			+0.4910	—0.1						F.
			+0.4917	—0.8						J.
		Mean	+0.4900							
*B. M. 5, Burney			+0.0032	—0.1	0.1		9.0303			F.
			+0.0030	+0.1						J.
		Mean	+0.0031							
*14-foot mark of water gauge, Carrollton.			+1.6128	+0.2	0.1		10.6402			F.
			+1.6132	—0.2						J.
		Mean	+1.6130							
*U. S. P. B. M. "Carrollton."			+0.1206				9.1478	0.0	9.1478	J.
*City B. M. marked [XX M. B., June, 1874].			—1.2617				7.7655			J.
T. B. M. 1	1.03	E	—1.6586	+1.2	0.8		7.3698			J.
		E	—1.6585	+1.1						J.
		W	—1.6538	—3.6						F.
		W	—1.6585	+1.1						F.
		Mean	—1.6574							
T. B. M. 2	3.38	E	+0.1150	—0.8	0.5		7.4840			J.
		W	+0.1135	+0.7						F.
		Mean	+0.1142							
U. S. P. B. M. 1	3.99	E	—0.5437	0.0	0.0	0.9	6.9403	—0.1	6.9402	J.
		W	—0.5437	0.0						F.
		W	—0.5436	—0.1						F.
		Mean	—0.5437							
*City stone at intersection Washington and Carrollton avenues.	3.66		+0.2793				7.7033			J.
T. B. M. 3	5.02	E	—0.4647	+1.8	1.2		6.4774			J.
		W	—0.4611	—1.8						F.
		Mean	—0.4629							
*City stone, "Halfway House."	6.65		+1.5096				7.9870			J.
*6.5-foot mark of gauge at West End, N. O	11.48		—0.3475				7.6305			F.
*B. M. "Height of Metairie Ridge."	11.74		+0.0359	—0.1	0.0		7.6753			F.
			+0.0358	0.0						F.
		Mean	+0.0358							
T. B. M. 4	5.66	E	+0.0259	+1.9	1.3		6.5052			J.
		W	+0.0298	—2.0						F.
		Mean	+0.0278							
T. B. M. 5	6.74	E	+0.7989	—0.2	0.1		7.3039			R.
		W	+0.7985	+0.2						F.
		Mean	+0.7987							

Results of precise leveling—Continued.

CARROLLTON, LA., TO BILOXI, MISS.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
*U. S. P. B. M. 2 ...	6.76	E	+1.8556	−0.2	0.1	2.0	9.1593	0.0	9.1593	R.
		W	+1.8552	+0.2	......	.....	....	......	....	F.
		Mean ..	+1.8554							
*City stone in city park.	8.14	E	−1.3546	+0.8	0.5	......	7.8055	......	....	F.
		W	−1.3530	−0.8	......	......	....	......	....	F.
		Mean ..	−1.3538							
U. S. P. B. M. 3	8.30	E	+0.3701	+0.7	0.5	2.1	7.6747	−0.1	7.6746	R.
		W	+0.3716	−0.8	......	......	....	......	....	F.
		Mean ..	+0.3708							
T. B. M. 7	9.27	E	+0.1131	−0.9	0.6	......	7.7889	......	....	R.
		W	+0.1133	+0.9	......	......	....	......	....	F.
		Mean ..	+0.1142							
T. B. M. 8	9.63	E	−0.2090	+1.4	0.9	......	7.5813	......	....	R.
		W	−0.2063	−1.3	......	......	....	......	....	F.
		Mean ..	−0.2076							
T. B. M. 9	11.86	E	+0.2124	+1.6	1.1	......	7.7953	......	....	R.
		W	+0.2156	−1.6	......	......	....	......	....	F.
		Mean ..	+0.2140							
T. B. M. 10	12.57	E	−0.7277	+0.7	0.4	......	7.0683	......	....	R.
		W	−0.7264	−0.6	......	......	....	......	....	F.
		Mean ..	−0.7270							
T. B. M. 12	13.88	E	+0.4251	+1.9	1.2	......	7.4953	......	....	R.
		W	+0.4288	−1.8	......	......	....	......	....	F.
		Mean ..	+0.4270							
T. B. M. 13	14.86	E	+0.0094	−1.2	0.8	......	7.5035	......	....	R.
		W	+0.0069	+1.3	......	......	....	......	....	F.
		Mean ..	+0.0082							
T. B. M. 14	16.20	E	+0.1884	−0.8	0.6	......	7.6911	......	....	R.
		W	+0.1867	+0.9	......	......	....	......	....	F.
		Mean ..	+0.1876							
T. B. M. 15	18.55	E	−0.5257	+0.4	0.3	......	7.1658	......	....	R.
		W	−0.5249	−0.4	......	......	....	......	....	F.
		Mean ..	−0.5253							
T. B. M. 16	19.29	E	−0.0533	+0.1	0.1	......	7.1126	......	....	R.
		W	−0.0530	−0.2	......	......	....	......	....	F.
		Mean ..	−0.0532							
T. B. M. 17	20.26	E	+0.5513	+0.9	0.6	......	7.6648	......	....	R.
		W	+0.5530	−0.8	......	......	....	......	....	F.
		Mean ..	+0.5522							
T. B. M. 18	20.90	E	−0.3580	+0.4	0.2	......	7.3072	......	....	R.
		W	−0.3573	−0.3	......	......	....	......	....	F.
		Mean ..	−0.3576							

Results of precise leveling—Continued.

CARROLLTON, LA., TO BILOXI, MISS.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 19	21.79	E	+0.1854	+0.4	0.2		7.4930			J.
		W	+0.1861	−0.3						F.
		Mean	+0.1858							
T. B. M. 20 and 20*a*	22.78	E	−0.2992	0.0	0.0		7.1938			J.
		W	−0.2993	+0.1						F.
		Mean	−0.2992							
T. B. M. 21	23.73	E	+0.0510	+0.6	0.4		7.2454			J.
		W	+0.0523	−0.7						F.
		Mean	+0.0516							
T. B. M. 22 and 22*a*	25.04	E	+0.3924	+0.7	0.5		7.6385			J.
		W	+0.3938	−0.7						F.
		Mean	+0.3931							
T. B. M. 23	26.76	E	+0.0898	−1.3	0.9		7.7270			J.
		W	+0.0872	+1.3						F.
		Mean	+0.0885							
T. B. M. 24 and 24*a*	28.29	E	−0.0978	−3.0	1.0		7.6262			J.
		W	−0.1050	+4.2						F.
		E	−0.1009	+0.1						J.
		W	−0.0997	−1.1						F.
		Mean	−0.1008							
T. B. M. 25 and 25*a*	29.92	E	−0.2830	+1.0	0.7		7.3442			J.
		W	−0.2810	−1.0						F.
		Mean	−0.2820							
T. B. M. 26	31.51	E	+0.3119	+1.9	1.3		7.6580			J.
		W	+0.3158	−2.0						F.
		Mean	=0.3138							
T. B. M. 27	33.08	E	−0.2046	−1.5	1.0		7.4519			J.
		W	−0.2076	+1.5						F.
		Mean	−0.2061							
T. B. M. 29 and 29*a*.	36.42	E	+0.0807	+3.4	2.4		7.5360			J.
		W	+0.0912	−7.1						F.
		W	+0.0804	+3.7						F.
		Mean	+0.0841							
T. B. M. 30 and 30*a*.	37.25	E	+0.5914	−0.4	0.3		8.1270			J.
		W	+0 5905	+0.5						F.
		Mean	+0.5910							
T. B. M. 31 and 31*a*.	37.82	E	+0.2347	−0.7	0.2		8.3610			J
		W	+0.2330	+0.4						F.
		E	+0.2333	+0.7						J.
		W	+0.2342	−0.2						F.
		Mean	+0.2340							
***U. S. P. B. M. 4**	38.10	E	+0.4191	−3.4	1.3	4.8	8.5427	0.0	8.5427	J.
		W	+0.4173	−1.6						F.
		W	+0.4101	+5.6						J.
		E	+0.4164	−0.7						J.
		Mean	+0.4157							

Results of precise leveling—Continued.

CARROLLTON, LA., TO BILOXI, MISS.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 32 and 32*a*.	39.67	E	—0.7311	—1.7	1.1		7.6282			J.
		W	—0.7345	+1.7						F.
		Mean	—0.7328							
T. B. M. 32½	41.24	E	+0.0944	+1.6	1.1		7.7242			J.
		W	+0.0994	—3.4						F.
		E	+0.0942	+1.8						J.
		Mean	+0.0960							
T. B. M. 33 and 33*a*.	42.32	E	+0.2304	+0.8	0.5		7.9554			J.
		W	+0.2319	—0.7						F.
		Mean	+0.2312							
T. B. M. 34 and 34*a*.	44.62	E	—0.5324	—2.4	1.6		7.4206			J.
		W	—0.5372	+2.4						F.
		Mean	—0.5348							
T. B. M. 35	46.81	E	+0.8463	—1.1	0.8		8.2658			J.
		W	+0.8440	+1.2						F.
		Mean	+0.8452							
T. B. M. 36	49.51	E	—0.0975	+0.5	0.4		8.1688			J.
		W	—0.0964	—0.6						F.
		Mean	—0.0970							
T. B. M. 37 and 37*a*.	51.65	E	—0.8964	—1.4	0.9		7.2710			R.
		W	—0.8991	+1.3						F.
		Mean	—0.8978							
T. B. M. 37½	52.70	E	+0.0117	+1.0	0.5		7.2837			R.
		W	+0.0140	—1.3						F.
		E	+0.0123	+0.4						J.
		Mean	+0.0127							
T. B. M. 38 and 38*a*.	53.62	E	—0.0449	+0.7	0.7		7.2395			R.
		W	—0.0420	—2.2						F.
		W	—0.0456	+1.4						F.
		Mean	—0.0442							
T. B. M. 39 and 39*a*.	56.57	E	+1.4625	+3.0	2.0		8.7050			J.
		W	+1.4685	—3.0						F.
		Mean	+1.4655							
*U. S. P. B. M. 5	56.92	W	—1.7545	+0.5	0.4	5.7	6.9510	—0.1	6.9509	F.
		W	—1.7534	—0.6						F.
		Mean	—1.7540							
T. B. M. 40 and 40*a*.	57.68	E	+0.0320	—0.5	0.4		8.7365			J.
		W	+0.0301	+1.4						F.
		E	+0.0311	+0.4						J.
		W	+0.0327	—1.2						F.
		Mean	+0.0315							
T. B. M. 41 and 41*a*.	58.62	E	—1.1105	—0.3	0.2		7.6257			R.
		W	—1.1111	+0.3						F.
		Mean	—1.1108							

Results of precise leveling—Continued.

CARROLLTON, LA., TO BILOXI, MISS.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm*	*Mm.*	*M.*	*Mm.*	*M*	
T. B. M. 42 and 42*a*.	60. 84	E	—0. 0942	0. 0	0. 0	......	18. 5173	......	....	J.
		W	—0. 0943	+0. 1	......	......	....	......	....	F.
		Mean ..	—0. 0942			......	....	......	....	F.
T B. M. 43	62. 48	E	+0. 2693	—0. 3	0. 2	......				
		W	+0. 2686	+0. 4	......	......	428	......	....	J.
		Mean ..	+0. 2690					......	....	F.
T. B. M. 44	63. 50	E	+0. 2820	+7. 4	1. 7	......	8. 0899	....		
		W	+0. 2914	—2. 0	......	......	....	......	[illegible]. 5133	R.
		E	+0. 2930	—3. 6	......	......	....	......	....	R.
		W	+0. 2910	—1. 6	......	......	....	......	....	
		Mean ..	+0. 2894							
T. B. M. 45 and 45*a*.	64. 98	E	—0. 2867	—0. 4	0. 3	......	7. 8028	......	....	J.
		W	—0. 2875	+0. 4	......	......	....	......	....	F.
		Mean ..	—0. 2871							
T. B. M. 46	66. 18	E	+0. 1890	+2. 1	1. 1	......	7. 9939	......	....	J.
		W	+0. 1943	—3. 2	......	......	....	......	....	F.
		E	+0. 1900	+1. 1	......	......	....	......	....	R.
		Mean ..	+0. 1911							
T. B. M. 47	67. 39	E	+0. 3090	+1. 0	0. 7	......	8. 3039	......	....	J.
		W	+0. 3111	—1. 1	......	......	....	......	....	F.
		Mean ..	+0 3100							
T. B. M. 48	67. 91	E	—0. 6378	0. 0	0. 2	......	7. 6661	......	....	J.
		W	—0. 6382	+0. 4	......	......	....	......	....	F.
		W	—0. 6373	—0. 5	......	......	....	......	....	F.
		Mean ..	—0. 6378							
*U. S. P. B. M. 6...	67. 97	....	+1. 8990	—0. 2	0. 2	6. 1	9. 5649	0. 0	9. 5649	F.
		....	+1. 8990	—0. 2	......	......	....	......	....	F.
		....	+1. 8983	+0. 5	......	......	....	......	....	J.
		Mean ..	+1. 8988							
T. B. M. 49 and 49*a*.	68. 98	E	+0. 5020	0. 0	0. 0	......	8. 1681	......	....	J.
		W	+0. 5019	+0. 1	......	......	....	......	....	F.
		Mean ..	+0. 5020							
T. B. M. 50	69. 86	E	—0. 1791	—0. 1	0. 0	......	7. 9889	......	....	J.
		W	—0. 1792	0. 0	......	......	....	......	....	F.
		Mean ..	—0. 1792							
*U. S. P. B. M. 7...	70. 41	E	—0. 3862	+0. 2	0. 1	6. 1	7. 6029	—0. 1	7. 6028	R.
		E	—0. 3859	—0. 1	......	......	....	......	....	R.
		Mean ..	—0. 3860							
T. B. M. 51 and 51*a*.	71. 49	E	+0. 1700	+0. 4	0. 3	......	8. 1593	......	....	J.
		W	+0. 1708	—0. 4	......	......	....	......	....	F.
		Mean ..	+0. 1704							
T. B. M. 52	72. 28	E	—0. 4413	—0. 5	0. 3	......	7. 7175	......	....	J.
		W	—0. 4423	+0. 5	......	......	....	......	....	F.
		Mean ..	—0. 4418							

Results of precise leveling—Continued.

CARROLLTON, LA., TO BILOXI, MISS.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 32 and 32*a*.	39.67	E	—0.4800	—1.6	1.0	......	8.1959	......	....	J.
		W	+0.4769	+1.5	......		....	......	....	F.
		Mean ..	+0.4784							
T. B. M. 32½	41.24	E	—0.3155	+0.1	0.1	......	7.8805	......	....	J.
		W	—0.3153	—0.1	......	......	....	......	....	F.
		Mean ..	—0.3154							
T. B. M. 33 and 3[illegible]	76.40	E	—0.3096	—0.6	0.4	......	7.5703	......	....	J.
		W	—0.3107	+0.5	......	......	....	......	....	F.
		Mean ..	—0.3102							
T. B. M. 56	78.36	E	+0.3038	—0.1	0.1	......	7.8740	......	....	R.
		W	+0.3036	+0.1	......	......	....	......	....	F.
		Mean ..	+0.3037							
T. B. M. 57	79.53	E	+0.3254	—1.1	0.7	......	8.1983	......	....	R.
		W	+0.3232	+1.1	......	......	....	......	....	F.
		Mean ..	+0.3243							
*U. S. P. B. M. 8...	79.10	E	+1.4204	......	......	6.2	9.2944	0.0	9.2944	J.
T. B. M. 58 and 58*a*.	80.87	E	+0.2752	+0.2	0.1	......	8.4737	......	....	R.
		W	+0.2756	—0.2	......	......	....	......	....	F.
		Mean ..	+0.2754							
T. B. M. 59	81.90	E	+1.2051	—0.2	0.1	......	9.6786	......	....	J.
		W	+1.2047	+0.2	......	......	....	......	....	F.
		Mean ..	+1.2049							
T. B. M. 60	83.17	E	—0.6781	+3.6	0.9	......	9.0041	......	....	J.
		W	—0.6723	—2.2	......	......	....	......	....	F.
		E	—0.6734	—1.1	......	......	....	......	....	J.
		W	—0.6741	—0.4	......	......	....	......	....	F.
		Mean ..	—0.6745							
T. B. M. 61 and 61*a*.	84.68	E	+2.3275	—0.1	0.3	......	11.3315	......	....	J.
		W	+2.3065	(†)	......	......	....	......	....	F.
		E	+2.3267	+0.7	......	......	....	......	....	J.
		W	+2.3280	—0.6	......	......	....	......	....	F.
		Mean ..	+2.3274							
*U. S. P. B. M. 9 ...	85.80	E	—0.2700	—1.0	0.6	6.4	11.0605	+0.1	11.0606	J.
		W	—0.2710	+0.9	......	......	....	......	....	F.
		Mean ..	—0.2710							
T. B. M. 62	85.43	E	+0.2808	—0.2	0.1	......	11.6121	......	....	J.
		W	+0 2804	+0.2	......	......	....	......	....	F.
		Mean ..	+0.2806							
T. B. M. 63	86.45	E	+0.1237	+0.1	0.1	......	11.7359	......	....	J.
		W	+0.1240	—0.2	......	......	....	......	....	F.
		Mean ..	+0.1238							
T. B. M. 64	88.28	E	+0.8683	+3.3	1.2	......	12.6075	......	....	J.
		W	+0.8744	—2.8	......	......	....	......	....	F.
		E	+0.8721	—0.5	......	......	....	......	....	J.
		Mean ..	+0.8716							

† Rejected.

Results of precise leveling—Continued.

CARROLLTON, LA., TO BILOXI, MISS.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M*	
T. B. M. 65	90. 15	E	+0. 9075	+2. 3	0. 9		13. 5173			J.
		W	+0. 9120	—2. 2						F.
		W	+0. 9100	—0. 2						F.
		Mean	+0. 9098							
T. B. M. 66 and 66*a*	91. 66	E	—1. 4738	—1. 2	0. 8		12. 0423			J.
		W	—1. 4762	+1. 2						F.
		Mean	—1. 4750							
*U. S. P. B. M. 10	91. 91	E	+1. 4717	—0. 9	0. 6	6. 6	13. 5131	+0. 2	13. 5133	R.
		W	+1. 4700	+0. 8						R.
		Mean	+1. 4708							
*U. S. P. B. M. 11	91. 68	E	+0. 8193	+0. 5	0. 3	6. 6	12. 8621	+0. 2	12. 8623	J.
		E	+0. 8202	—0. 4						F.
		Mean	+0. 8198							
U. S. P. B. M. 12	95. 41	E	—2. 7030	—0. 2	0. 5		9. 3391	0. 0	9. 3391	J.
		E	—2. 7016	—1. 6						J.
		W	—2. 7053	+2. 1						F.
		W	—2. 7028	—0. 4						F.
		Mean	—2. 7032							
T. B. M. 69 and 69*a*	97. 66	E	—0. 0470	—0. 9	0. 6		9. 2912			J.
		W	—0. 0488	+0. 9						F.
		Mean	—0. 0479							
T. B. M. 70 and 70*a*.	100. 23	E	+0. 2941	+8. 0	1. 6		9. 5933			R.
		W	+0. 2994	+2. 7						F.
		E	+0. 3040	—1. 9						J.
		E	+0. 3064	—4. 3						J.
		W	+0. 3064	—4. 3						F.
		Mean	+0. 3021							
T. B. M. 71	102. 18	E	+2. 5050	+2. 4	0. 9		12. 1007			J.
		W	+2. 5095	—2. 1						F.
		W	+2. 5078	—0. 4						F.
		Mean	+2. 5074							
*U. S. P. B. M. 13	100. 27	E	+0. 1430	—0. 4	0. 3	6. 8	9. 7359	0. 0	9. 7359	J.
		W	+0. 1422	+0. 4						F.
		Mean	+0. 1426							
T. B. M. 72	103. 54	E	—0. 0177	+0. 7	0. 5		12. 0837			J.
		W	—0. 0163	—0. 7						F.
		Mean	—0. 0170							
T. B. M. 73 and 73*a*.	105. 13	E	+2. 6072	+0. 2	0. 2		14. 6911			J.
		W	+2. 6077	—0. 3						F.
		Mean	+2. 6074							
T. B. M. 74 and 74*a*.	106. 53	E	+1. 4524	+1. 0	0. 7		16. 1445			J.
		W	+1. 4545	—1. 1						F.
		Mean	+1. 4534							
*U. S. P. B. M. 14	106. 65	E	—0. 3790	—0. 4	0. 3	7. 0	15. 7651	+0. 3	15. 7654	J.
		E	-0. 3799	+0. 5						F.
		Mean	—0. 3794							

Results of precise leveling—Continued.

CARROLLTON, LA., TO BILOXI, MISS.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 75	108. 11	E	—1. 3508	+1. 4	1. 0		14. 7951			J.
		W	—1. 3479	—1. 5						F.
		Mean	—1. 3494							
T. B. M. 76 and 76*a*.	109. 69	E	+0. 0615	—0. 7	0. 5		14. 8559			J.
		W	+0. 0600	+0. 8						F.
		Mean	+0. 0608							
T. B. M. 77	111. 05	E	—0. 7292	—0. 5	0. 3		14. 1262			J.
		W	—0. 7302	+0. 5						F.
		Mean	—0. 7297							
T. B. M. 78 and 78*a*.	112. 15	E	—0. 5689	+2. 1	1. 4		13. 5594			J.
		W	—0. 5648	—2. 0						F.
		Mean	—0. 5668							
*U. S. P. B. M. 15	112. 25	E	+0. 5097	+1. 5	1. 0	7. 2	14. 0706	+0. 2	14. 0708	J.
		W	+0. 5128	—1. 6						F.
		Mean	+0. 5112							
T. B. M. 79	113. 28	E	—0. 0952	+0. 2	0. 1		13. 4644			J.
		W	—0. 0948	—0. 2						F.
		Mean	—0. 0950							
T. B. M. 80 and 80*a*.	114. 55	E	+0. 5190	+2. 4	1. 6		13. 9858			J.
		W	+0. 5238	—2. 4						F.
		Mean	+0. 5214							
T. B. M. 81	116. 16	E	—0. 1494	+1. 6	1. 0		13. 8380			J.
		W	—0. 1463	—1. 5						F.
		Mean	—0. 1478							
T. B. M. 82	117. 76	E	—0. 4223	—0. 1	0. 0		13. 4156			J.
		W	—0. 4224	0. 0						F.
		Mean	—0. 4224							
T. B. M. 83	118. 98	E	—0. 7872	+0. 2	0. 1		12. 6286			J.
		W	—0. 7869	—0. 1						F.
		Mean	—0. 7870							
T. B. M. 84 and 84*a*.	120. 31	E	+0. 3032	—0. 4	0. 2		12. 9314			J.
		W	+0. 3025	+0. 3						F.
		Mean	+0. 3028							
*U. S. P. B. M. 16	120. 58	E	—0. 1892	+0. 4	0. 3	7. 4	12. 7426	+0. 2	12. 7428	J.
		W	—0. 1883	—0. 5						F.
		Mean	—0. 1888							
T. B. M. 85	121. 95	E	+0. 4903	—0. 9	0. 6		13. 4208			J.
		W	+0. 4884	+1. 0						F.
		Mean	+0. 4894							
T. B. M. 86 and 86*a*.	123. 76	E	+0. 1588	+1. 7	1. 1		13. 5813			J.
		W	+0. 1622	—1. 7						F.
		Mean	+0. 1605							

Results of precise leveling—Continued.

CARROLLTON, LA., TO BILOXI, MISS.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 87	125.42	E	+0.5981	+0.3	0.2		14.1797			J.
		W	+0.5987	−0.3						F.
		Mean	+0.5984							
T. B. M. 88	126.61	E	−0.4868	+0.8	0.6		13.6937			J.
		W	−0.4851	−0.9						F.
		Mean	−0.4860							
T. B. M. 89 and 89*a*.	127.99	E	+0.6224	+0.6	0.4		14.3167			J.
		W	+0.6237	−0.7						F.
		Mean	+0.6230							
*U. S. P. B. M. 17	128.02	E	−0.0846	−0.1	0.1	7.6	14.2320	+0.2	14.2322	J.
		W	−0.0848	+0.1						F.
		Mean	−0.0847							
T. B. M. 90 and 90*a*.	129.77	E	+0.2909	+2.5	1.6		14.6101			J.
		W	+0.2958	−2.4						F.
		Mean	+0.2934							
T. B. M. 91	130.81	E	+0.6190	−1.4	0.9		15.2277			J.
		W	+0.6162	+1.4						F.
		Mean	+0.6176							
T. B. M. 92 and 92*a*.	132.07	E	−1.5360	+1.0	0.7		13.6927			J.
		W	−1.5340	−1.0						F.
		Mean	−1.5350							
T. B. M. 93 and 93*a*.	133.22	E	+0.6670	+0.8	0.6		14.3605			J.
		W	+0.6687	−0.9						F.
		Mean	+0.6678							
T. B. M. 94	134.60	E	−0.7531	+1.5	1.0		13.6089			J.
		W	−0.7501	−1.5						F.
		Mean	−0.7516							
T. B. M. 95 and 95*a*.	136.17	E	−1.9825	+0.5	0.4		11.6269			J.
		W	−1.9814	−0.6						F.
		Mean	−1.9820							
*U. S. P. B. M. 18	136.61	E	+1.4731	+0.4	0.3	7.9	13.1004	+0.2	13.1006	J.
		W	+1.4739	−0.4						F.
		Mean	+1.4735							
T. B. M. 96	137.43	E	−1.4971	−0.9	0.6		10.1289			J.
		W	−1.4989	+0.9						F.
		Mean	−1.4980							
U. S. P. B. M. 20	138.94	E	−1.6168	+0.4	0.2	7.9	8.5125	0.0	8.5125	R.
		W	−1.6161	−0.3						F.
		Mean	−1.6164							
*U. S. P. B. M. 19	139.09	E	−0.3447	+0.2	0.1	7.9	8.1680	0.0	8.1680	R.
		W	−0.3443	−0.2						F.
		Mean	−0.3445							

Results of precise leveling—Continued.

CARROLLTON, LA., TO BILOXI, MISS.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
U. S. P. B. M. 21	140.02	E	−1.8027	+1.4	0.5	8.0	6.7112	−0.1	6.7111	J.
		W	−1.8010	−0.8						F.
		E	−1.7993	−2.0						R.
		W	--1.8022	+0.9						F.
		Mean	−1.8013							
8-foot mark of tide-gauge at Biloxi.	140.05	E	+0.2386	+0.4	0.3	8.0	6.9502	−0.1	6.9501	F.
		W	+0.2394	−0.4						F.
		Mean	+0.2390							

GRAFTON, ILL., TO CAIRO, ILL.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
U. S. P. B. M. 1							134.5098	+0.3	134.5101	
T. B. M. 4	0.05	N	−0.8814	+0.2	0.1		133.6286			F.
		S	−0.8811	−0.1						F.
		Mean	−0.8812							
T. B. M. 3	0.48	S	+0.1305		1.3		133.7634			F.
		N	+0.1418							F.
		S	+0.1335							F.
(River crossing, Illinois River.)		N	+0.1335							F.
		N	+0.1471	−4.0						P.
		S	+0.1249	+1.4						P.
		N	+0.1407	−2.3						P.
		S	+0.1264	+4.8						P.
		Mean	+0.1348							
U. S. P. B. M. 2	0.55	S	+2.6021	−1.3	0.8	1.5	136.3642	+0.3	136.3645	F.
		N	+2.5996	+1.2						F.
		Mean	+2.6008							
*H. M. mark, July 9, 1880.							135.3311			
U. S. P. B. M. 3	2.68	S	+2.9416	+5.5	1.9	2.4	139.3113	+0.3	139.3116	P.
		N	+2.9512	−4.1						P.
		N	+2.9484	−1.3						P.
		Mean	+2.9471							
T. B. M. 2	3.58	S	−4.7659	0.0	0.0		134.5454			P.
		N	−4.7659	0.0						P.
		Mean	−4.7659							
U. S. P. B. M. 4	4.28	S	+7.5228	+3.4	1.1	2.7	142.0716	+0.3	142.0719	P.
		N	+7.5282	−2.0						P.
		S	+7.5275	--1.3						P.
		Mean	+7.5262							
*219-foot mark of gauge at Grafton.							137.6846			
Mackenzie, B. M.	4.43	S	−2.6422	+0.2	0.2		139.4296			P.
		N	−2.6417	−0.3						P.
		Mean	−2.6420							
T. B. M. 5	5.25	N	−5.5997	+9.1	4.2		133.8392			P.
		S	−5.5901	−0.5						P.
		N	−5.5988	+8.2						P.
		S	−5.5781	−17.5						F.
		Mean	−5.5904							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
U. S. P. B. M. 5	10.68	S	+7.5875	+3.5	2.3	5.5	141.4302	+0.3	141.4305	F.
		N	+7.5944	-3.4						P.
		Mean	+7.5910							
T. B. M. 14	13.37	S	-9.6157	-3.3	2.2		131.8112			F.
		N	-9.6222	+3.2						P.
		Mean	-9.6190							
T. B. M. 15	14.38	N	+0.1379	+0.7	0.5		131.9498			P.
		S	+0.1393	-0.7						F.
		Mean	+0.1386							
T. B. M. 16	15.39	S	-0.8453	+4.0	2.0		131.1085			F.
		N	-0.8355	-5.8						P.
		N	-0.8431	+1.8						F.
		Mean	-0.8413							
U. S. P. B. M. 6	15.83	S	+3.9243	+0.8	0.5	6.3	135.0336	+0.3	135.0339	F.
		N	+3.9259	-0.8						P.
		Mean	+3.9251							
T. B. M. 18	18.02	S	-1.1456	-1.2	0.8		133.8868			F.
		N	-1.1480	+1.2						P.
		Mean	-1.1468							
T. B. M. 20	19.13	N	-2.4954	-4.8	2.1		131.3866			P.
		S	-2.5059	+5.7						F.
		N	-2.4994	-0.8						F.
		Mean	-2.5002							
T. B. M. 21	19.78	S	+0.2852	-2.0	1.3		131.6698			F.
		N	+0.2813	+1.9						P.
		Mean	+0.2832							
T. B. M. 23	21.13	N	-1.6478	-1.6	1.1		130.0204			P.
		S	-1.6510	+1.6						F.
		Mean	-1.6494							
T. B. M. 25	22.29	S	+5.4806	-1.0	0.4		135.5000			F.
		N	+5 4797	-0.1						P.
		S	+5.4786	+1.0						F.
		Mean	+5.4796							
*U. S. P. B. M. 7		S	+8.2185	-0.7	0.4	6.9	143.7178	+0.3	143.7181	P.
		N	+8.2172	+0.6						P.
		Mean	+8.2178							
T. B. M. 27	23.77	S	-4.7250	+2.9	1.7		130.7779			F.
		N	-4.7169	-5.2						P.
		N	-4.7243	+2.2						F.
		Mean	-4.7221							
T. B. M. 28	24.93	S	-0.6382	-1.2	0.8		130.1385			F.
		N	-0.6407	+1.3						P.
		Mean	-0.6394							
U. S. P. B. M. 8	27.76	N	+6.8074	+0.6	0.4	7.1	136.9465	+0.3	136.9468	P.
		S	+6.8086	-0.6						F.
		Mean	+6.8080							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
*209-foot mark of gauge at Alton.							134.9313			
T. B. M. 31	28.27	S	+1.7355	-1.2	0.8		138.6808			F.
		N	+1.7331	+1.2						P.
		Mean	+1.7343							
U. S. P. B. M. 9	29.24	S	+15.7809	-0.9	0.6	7.2	154.4608	+0.4	154.4612	F.
		N	+15.7790	+1.0						P.
		Mean	+15.7800							
T. B. M. 33	30.08	S	-16.3592	-4.3	1.7		138.0973			F.
		N	-16.3677	+4.2						F.
		S	-16.3635	0.0						F.
		Mean	-16.3635							
T. B. M. 34	30.99	S	-5.2816	-1.1	0.6		132.8146			F.
		N	-5.2846	+1.9						P.
		S	-5.2820	-0.7						F.
		Mean	-5.2827							
T. B. M. 35	32.30	S	-0.1278	+2.2	1.4		132.6890			F.
		N	-0.1235	-2.1						P.
		Mean	-0.1256							
T. B. M. 38	34.36	S	+2.7052	+0.7	0.5		135.3949			F.
		N	+2.7066	-0.7						P.
		Mean	+2.7059							
U. S. P. B. M. 10	35.95	N	+0.6508	-0.3	0.2	7.6	136.0454	+0.3	136.0457	P.
		S	+0.6502	+0.3						F.
		Mean	+0.6505							
T. B. M. 42	38.40	S	-3.2442	+2.7	1.8		132.8039			F.
		S	-3.2388	-2.7						F.
		Mean	-3.2415							
T. B. M. 44	40.18	S	-0.1474	+2.2	1.5		132.6587			F.
		N	-0.1429	-2.3						F.
		Mean	-0.1452							
*U. S. P. B. M. 11		S	-0.4275	-0.3	0.2	8.0	132.2309	+0.3	132.2312	F.
		N	-0.4281	+0.3						F.
		Mean	-0.4278							
T. B. M. 45	41.06	S	-0.2674	-3.2	1.1		132.3881			F.
		N	-0.2722	+1.6						F.
		N	-0.2721	+1.5						P.
		Mean	-0.2706							
T. B. M. 46	41.51	S	-2.3550	+1.1	0.7		130.0342			P.
		N	-2.3528	-1.1						P.
		Mean	-2.3539							
T. B. M. 47 (river crossing, Mississippi River).	42.00	S	-0.0445		0.6		130.0046			F.
		N	-0.0162							F.
		N	-0.0126	-1.0						P.
		S	-0.0449	+0.9						P.
		Mean	-0.0296							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 53	45.76	S	+1.8580	+0.6	0.4		131.8632			P.
		S	+1.8593	−0.7						F.
		Mean	+1.8586							
T. B. M. 58	48.60	S	+8.0673	−2.9	2.0		139.9276			F.
		S	+8.0614	+3.0						P.
		Mean	+8.0644							
U. S. P. B. M. 12	49.41	S	+5.7337	−0.5	0.4	8.4	145.6608	+0.3	145.6611	P.
		S	+5.7326	+0.6						F.
		Mean	+5.7332							
T. B. M. 61	51.03	S	−5.6617	−1.0	0.6		139.9981			P.
		S	−5.6637	+1.0						F.
		Mean	−5.6627							
T. B. M. 62	51.85	S	+3.0020	−0.6	0.4		142.9995			P.
		S	+3.0007	+0.7						F.
		Mean	+3.0014							
T. B. M. 65	54.59	S	−5.1755	+1.5	1.0		137.8255			P.
		S	−5.1726	−1.4						F.
		Mean	−5.1740							
T. B. M. 67	56.22	S	−2.3581	+5.3	1.8		135.4727			P.
		N	−2.3508	−2.0						S.
		S	−2.3494	−3.4						F.
		Mean	−2.3528							
T. B. M. 69	57.29	S	+3.9197	−1.5	1.0		139.3909			F.
		S	+3.9168	+1.4						P.
		Mean	+3.9182							
T. B. M. 70	58.30	S	−2.4299	−1.3	0.6		136.9597			F.
		S	−2.4330	+1.8						P.
		N	−2.4307	−0.5						S.
		Mean	−2.4312							
U. S. P. B. M. 13	58.91	S	+0.6845	+0.2	0.5	8.7	137.6444	+0.3	137.6447	F.
		N	+0.6834	+1.3						S.
		S	+0.6861	−1.4						S.
		Mean	+0.6847							
T. B. M. 71	59.62	S	+0.1868	+0.6	0.4		137.8318			F.
		N	+0.1880	−0.6						S.
		Mean	+0.1874							
T. B. M. 75	62.62	N	+3.6056	+1.0	0.7		141.4384			S.
		S	+3.6076	−1.0						F.
		Mean	+3.6066							
T. B. M. 76	63.66	S	−0.7366	−0.6	0.4		140.7012			F.
		N	−0.7379	+0.7						S.
		Mean	−0.7372							
T. B. M. 77	64.56	S	−5.5370	−2.0	1.3		135.1622			F.
		N	−5.5409	+1.9						S.
		Mean	−5.5390							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
*U. S. P. B. M. 14	....	N	+0.9570	+0.6	0.4	8.8	136.1198	+0.3	136.1201	P.
		S	+0.9581	−0.5	......	......	....	......	....	P.
		Mean ..	+0.9576							
*B. M. on high-service chimney, Saint Louis water-works.	....	N	−1.2800	−0.1	0.1	......	134.8397	......	....	P.
		S	−1.2802	+0.1	......	......	....	......	....	P.
		Mean ..	−1.2801							
*B. M. on low-service chimney, Saint Louis water-works.	....	N	+0.4872	−2.6	1.7	......	135.3243	......	....	P.
		S	+0.4820	+2.6	......	......	....	......	....	P.
		Mean ..	+0.4846							
*B. M. on cotton-wood tree, Saint Louis water-works.	....	N	−2.2877	−0.7	0.4	......	133.0359	......	....	P.
		S	−2.2890	+0.6	......	......	....	......	....	P.
		Mean ..	−2.2884							
*89-foot mark of water-gauge at Saint Louis water-works.	....	N	−4.2622	+0.7	0.5	......	128.7744	......	....	P.
		S	−4.2608	−0.7	......	......	....	......	....	P.
		Mean ..	−4.2615							
T. B. M. 81	66.52	S	+3.0183	−0.9	0.6	......	138.1796	......	....	F.
		N	+3.0166	+0.8	......	......	....	......	....	S.
		Mean ..	+3.0174							
T. B. M. 83	67.84	S	+4.8850	+2.2	1.5	......	143.0624	......	....	F.
		S	+4.8805	−2.3	......	......	....	......	....	P.
		Mean ..	+4.8828							
T. B. M. 85	68.66	S	+8.0560	+3.3	1.1	......	151.1217	......	....	F.
		N	+8.0615	−2.2	......	......	....	......	....	F.
		S	+8.0605	−1.2	......	......	....	......	....	F.
		Mean ..	+8.0593							
T. B. M. 87	69.82	S	−18.9394	+1.0	0.6	......	132.1833	......	....	F.
		N	−18.9375	−0.9	......	......	....	......	....	F.
		Mean ..	−18.9384							
*U. S. P. B. M. 15 ..	....	S	+0.9093	+1.0	0.8	9.1	133.0936	+0.2	133.0938	S.
		S	+0.9108	−0.5	......	......	....	......	....	F.
		N	+0.9109	−0.6	......	......	....	......	....	F.
		Mean ..	+0.9103							
City Directrix, Saint Louis, Mo.	70.51	S	+0.0917	−1.0	0.7	9.1	132.2740	+0.2	132.2742	F.
		N	+0.0897	+1.0	......	......	....	......	....	S.
		Mean ..	+0.0907							
*30-foot mark of water-gauge at Saint Louis, Mo.	....	....	....	......	......	......	131.1331	......	....	
T. B. M. 89	71.37	S	+0.8749	+0.9	0.6	......	133.1498	......	....	F.
		N	+0.8766	−0.8	......	......	....	......	....	S.
		Mean ..	+0.8758							
T. B. M. 92	73.17	S	+1.0174	+0.9	0.6	......	134.1681	......	....	F.
		N	+1.0192	−0.9	......	......	....	......	....	S.
		Mean ..	+1.0183							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 96	75.62	S	+22.8696	+0.6	0.4	......	157.0383	......	....	F.
		N	+22.8707	−0.5	......	......	....	......	....	S.
		Mean	+22.8702							
U. S. P. B. M. 16	77.60	S	+2.3069	+0.5	0.3	9.2	159.3457	+0.4	159.3461	F.
		N	+2.3079	−0.5	......	......	....	......	....	S.
		Mean	+2.3074							
T. B. M. 100	79.90	S	−0.4785	−0.3	0.2	......	158.8669	......	....	F.
		S	−0.4790	+0.2	......	......	....	......	....	P.
		Mean	−0.4788							
U. S. P. B. M. 17	82.43	S	−20.1856	+0.4	0.2	9.2	138.6817	+0.3	138.6820	F.
		S	−20.1849	−0.3	......	......	....	......	....	P.
		Mean	−20.1852							
T. B. M. 104	83.44	S	−0.8865	+0 2	0.1	......	137.7954	......	....	F.
		N & S	−0.8861	−0.2	......	......	....	......	....	P.
		Mean	−0.8863							
*B. M. 1, Holman	....	S	−3.2617	+1.1	0.7	......	134.5348	......	....	F.
		N	−3.2595	−1.1	......	......	....	......	....	F.
		Mean	−3.2606							
T. B. M. 105	83.78	S	−6.9739	−1.0	0.7	......	130.8205	......	....	F.
		N	−6.9759	+1.0	......	......	....	......	....	P.
		Mean	−6.9749							
T. B. M. 106	84.59	S	+20.7024	−1.3	0.9	......	160.5216	......	....	F.
		N	+29.6998	+1.3	......	......	....	......	....	P.
		Mean	+29.7011							
T. B. M. 109	86.73	S	−7.7744	+2.7	1.8	......	152.7499	......	....	F.
		N	−7.7690	−2.7	......	......	....	......	....	P.
		Mean	−7.7717							
T. B. M. 112	88.33	S	+4.0928	−2.0	1.3	......	156.8407	......	....	F.
		N	+4.0888	+2.0	......	......	....	......	....	S.
		Mean	+4.0908							
*U. S. P. B. M. 18	....	S	+0.0579	+0.2	0.1	9.5	156.8988	+0.4	156.8992	F.
		N	+0.0584	−0.3	......	......	....	......	....	F.
		S	+0.0581	0.0	......	......	....	......	....	P.
		Mean	+0.0581							
B. M. 6, Holman	89.18	S	−24.4483	+0.1	0.0	......	132.3925	......	....	F.
		N	−24.4482	0.0	......	......	....	......	....	P.
		Mean	−24.4482							
T. B. M. 114	89.63	S	+1.3173	+1.6	1.0	......	133.7113	......	....	F.
		N	+1.3203	−1.5	......	......	....	......	....	P.
		Mean	+1.3188							
B. M. 7, Holman	90.90	S.	+0.4811	−0.4	0.2	......	134.1920	......	....	S.
		N	+0.4804	+0.3	......	......	....	......	....	P.
		Mean	+0.4807							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
B. M. 8, Holman	91.78	S	+0.9021	+2.6	1.8		135.0967			S.
		N	+0.9074	−2.7						P.
		Mean	+0.9047							
B. M. 9, Holman	92.75	S	−1.3792	−3.8	2.6		133.7137			S.
		N	−1.3869	+3.9						P.
		Mean	−1.3830							
T. B. M. 118	93.89	S	−0.9828	+3.1	1.1		132.7340			S.
		S	−0.9777	−2.0						S.
		N	−0.9786	−1.1						P.
		Mean	−0.9797							
*U. S. P. B. M. 19		S	−6.5393	0.0	0.0	10.1	126.1947	+0.2	126.1949	P.
		N	−6.5393	0.0						P.
		Mean	−6.5393							
T. B. M. 119	94.68	S	+0.6307	+2.1	1.4		133.3668			S.
		N	+0.6350	−2.2						P.
		Mean	+0.6328							
B. M. 10, Holman	95.12	S	+0.0628	−0.4	0.3		133.4292			F.
		N	+0.0620	+0.4						P.
		Mean	+0.0624							
B. M. 11, Holman	97.10	S	+1.1273	+2.4	1.6		134.5589			F.
		N	+1.1321	−2.4						P.
		Mean	+1.1297							
B. M. 12, Holman	99.36	S	−1.8177	−3.7	2.5		132.7375			F.
		N	−1.8252	+3.8						S.
		Mean	−1.8214							
U. S. P. B. M. 20	99.40	S	−1.6422	+1.2	0.9	10.7	131.0965	+0.2	131.0967	F.
		N	−1.6423	+1.3						S.
		S	−1.6384	−2.6						P.
		Mean	−1.6410							
T. B. M. 124	100.59	S	+2.0564	−0.2	0.1		133.1527			F.
		S	+2.0560	+0.2						P.
		Mean	+2.0562							
B. M. 13, Holman	100.93	S	+0.7609	+0.3	0.2		133.9139			F.
		N	+0.7615	−0.3						P.
		Mean	+0.7612							
T. B. M. 125	101.45	S	−1.1589	+1.3	0.9		132.7563			F.
		N	−1.1562	−1.4						P.
		Mean	−1.1576							
B. M. 14, Holman	102.49	S	−0.4530	+1.8	1.2		132.3051			F.
		N	−0.4495	−1.7						P.
		Mean	−0.4512							
T. B. M. 126	102.82	S	−0.2059	+0.1	0.0		132.0993			F.
		N	−0.2058	0.0						P.
		Mean	−0.2058							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
B. M. 15, Holman	103.98	S	+1.0999	+4.5	1.6		133.2037			F.
		N	+1.1078	−3.4						P.
		S	+1.1056	−1.2						S.
		Mean	+1.1044							
U. S. P. B. M. 21	104.28	S	−3.1576	+0.6	0.4	10.8	130.0467	+0.2	130.0469	F.
		N	−3.1576	+0.6						P.
		S	−3.1559	−1.1						S.
		Mean	−3.1570							
T. B. M. 128	106.37	S	+4.9989	+4.7	2.6		135.0503			F.
		S	+5.0112	−7.6						S.
		N	+5.0008	+2.8						S.
		Mean	+5.0036							
U. S. P. B. M. 22	107.16	S	−4.3616	+1.2	0.8	11.2	130.6899	+0.2	130.6901	F.
		N	−4.3593	−1.1						S.
		Mean	−4.3604							
B. M. 18, Holman	107.84	S	+0.9915	+0.1	0.1		131.6815			F.
		N	+0.9918	−0.2						S.
		Mean	+0.9916							
B. M. 19, Holman	108.94	S	+1.6970	+1.4	0.9		133.3799			F.
		N	+1.6998	−1.4						S.
		Mean	+1.6984							
B. M. 20, Holman	110.46	S	−2.5190	+0.8	0.6		130.8617			F.
		S	−2.5173	−0.9						F.
		Mean	−2.5182							
U. S. P. B. M. 23	110.74	S	−1.5524	+0.8	0.6	11.4	129.3101	+0.2	129.3103	F.
		S	−1.5507	−0.9						F.
		Mean	−1.5516							
T. B. M., 130	111.36	S	+1.6789	−0.6	0.4		130.9684			F.
		S	+1.6777	+0.6						F.
		Mean	+1.6783							
B. M. 21, Holman	112.29	S	+0.8414	−0.8	0.5		131.8290			F.
		N	+0.8399	+0.7						P.
		Mean	+0.8406							
B. M. 22, Holman	113.90	S	+0.5794	−0.6	0.4		132.4078			F.
		N	+0.5782	+0.6						P.
		Mean	+0.5788							
B. M. 23, Holman	115.48	N	+4.7903	−2.4	1.6		137.1957			F.
		N	+4.7855	+2.4						P.
		Mean	+4.7879							
T. B. M. 133	115.67	N	−0.1324	+0.2	0.1		137.0635			F.
		N	−0.1321	0.1						P.
		Mean	−0.1322							
U. S. P. B. M. 24	116.75	S	−5.3121	+0.9	0.6	11.5	131.7523	+0.2	131.7525	F.
		N	−5.3102	−1.0						P.
		Mean	−5.3112							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 134	117.63	S	−8.9996	−2.5	1.0	......	122.7502	......	....	F.
		S	−9.0046	+2.5	......	......	....	......	....	S.
		S	−9.0021	0.0	......	......	....	......	....	S.
		Mean ..	−9.0021							
B. M. 25, Holman ..	118.25	S	+2.0595	+0.2	0.1	......	124.8099	......	....	S.
		S	+2.0599	−0.2	......	......	....	......	....	F.
		Mean ..	+2.0597							
T. B. M. 135	119.26	S	−2.3115	−2.5	1.7	......	122.4959	......	....	S.
		S	−2.3166	+2.6	......	......	....	......	....	F.
		Mean ..	−2.3140							
T. B. M. 136	120.14	S	−0.4075	−3.7	1.3	......	122.0847	......	....	S.
		S	−0.4135	+2.3	......	......	....	......	....	F.
		N	−0.4127	+1.5	......	......	....	......	....	P.
		Mean ..	−0.4112							
T. B. M. 138	121.05	S	+2.3835	−2.3	1.8	......	124.4659	......	....	S.
		S	+2.3758	+5.4	......	......	....	......	....	F.
		N	+2.3842	−3.0	......	......	....	......	....	P.
		Mean ..	+2.3812							
T. B. M. 139	121.89	S	−0.4909	−0.7	0.5	......	123.9743	......	....	S.
		S	−0.4923	+0.7	......	......	....	......	....	F.
		Mean ..	−0.4916							
T. B. M. 141	122.97	S	+3.8433	+4.0	1.5	......	127.8216	......	....	F.
		N	+3.8512	−3.9	......	......	....	......	....	P.
		S	−3.8473	0.0	......	......	....	......	....	P.
		Mean ..	+3.8473							
T. B. M. 142	123.72	S	−0.6375	−1.1	0.8	......	127.1830	......	....	F.
		N	−0.6398	+1.2	......	......	....	......	....	P.
		Mean ..	−0.6386							
U. S. P. B. M. 25 ...	125.22	S	−3.5437	−0.3	0.2	12.0	123.6390	+0.2	123.6392	F.
		N	−3.5442	+0.2	......	......	....	......	....	P.
		Mean ..	−3.5440							
B. M. 31, Holman ..	126.96	S	−0.1413	−2.9	1.9	......	123.4948	......	....	F.
		N	−0.1471	+2.9	......	......	....	......	....	P.
		Mean ..	−0.1442							
B. M. 32, Holman ..	128.60	S	−0.6353	+2.5	1.7	......	122.8620	......	....	F.
		N	−0.6302	−2.6	......	......	....	......	....	P.
		Mean ..	−0.6328							
T. B. M. 149	129.58	S	−2.0903	−0.3	0.2	......	120.7714	......	....	F.
		N	−2.0908	+0.2	......	......	....	......	....	P.
		Mean ..	−2.0906							
B. M. 33, Holman ..	130.06	S	+2.3763	−1.3	0.8	......	123.1464	......	....	F.
		N	+2.3738	+1.2	......	......	....	......	....	P.
		Mean ..	+2.3750							
B. M. 34, Holman ..	131.43	S	−1.3996	+2.4	1.6	......	121.7492	......	....	F.
		N	−1.3947	−2.5	......	......	....	......	....	P.
		Mean ..	−1.3972							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
B. M. 35, Holman..	132.91	S	+1.0984	—1.0	0.7	......	122.8466	......	....	F.
		N	+1.0964	+1.0	......	......	....	......	....	P.
		Mean..	+1.0974							
*U. S. P B. M. 26 ..	....	....	+1.8112	—0.2	0.1	12.4	124.6576	+0.2	124.6578	P.
		....	+1.8109	+0.1	......	......	....	......	....	P.
		Mean..	+1.8110							
U. S. P. B. M. 27 ...	134.63	N	+3.8334	—1.2	0.8	12.4	126.6788	+0.2	126.6790	P.
		S	+3.8311	+1.1	......	......	....	......	....	F.
		Mean..	+3.8322							
*34-foot mark of water-gauge at Rush Tower, Mo.	....	....	....	......	......	......	123.9558	......	....	
T. B. M. 153	136.81	S	—3.3630	+1.2	0.8	......	123.3170	......	....	F.
		S	—3.3606	—1.2	......	......	....	......	....	P.
		Mean..	—3.3618							
T. B. M. 156	139.82	S	+0.4072	+0.5	0.3	......	123.7247	......	....	F.
		S	+0.4082	—0.5	......	......	....	......	....	P.
		Mean..	+0.4077							
T. B. M. 157	140.75	S	—1.0716	+4.5	1.7	......	122.6576	......	....	F.
		N	—1.0669	—0.2	......	......	....	......	....	F.
		S	—1.0629	—4.2	......	......	....	......	....	P.
		Mean..	—1.0671							
T. B. M. 160	142.28	S	+0.8712	0.0	0.0	......	123.5288	......	....	F.
		N	+0.8711	+0.1	......	......	....	......	....	F.
		Mean..	+0.8712							
T. B. M. 163	143.85	S	—0.8113	+1.7	1.1	......	122.7192	......	....	F.
		N	—0.8079	—1.7	......	......	....	......	....	F.
		Mean..	—0.8096							
U. S. P. B. M. 28 ...	144.41	S	—1.1708	+0.2	0.2	12.6	121.5486	+0.1	121.5487	F.
		N	—1.1703	—0.3	......	......	....	......	....	F.
		Mean .	—1.1706							
B. M. 40, Holman..	145.64	S	—1.7538	—1.8	2.3	......	119.7930	......	....	F.
		S	—1.7622	+6.6	......	......	....	......	....	F.
		N	—1.7508	—4.8	......	......	....	......	....	F.
		Mean..	—1.7556							
B. M. 41, Holman..	146.40	S	+1.4165	+1.3	0.9	......	121.2108	......	....	F.
		S	+1.4191	—1.3	......	......	....	......	....	F.
		Mean..	+1.4178							
B. M. 43, Holman..	149.72	S	—2.8154	—1.0	0.6	......	118.3944	......	....	F.
		N	—2.8173	+0.9	......	......	....	......	....	P.
		Mean..	—2.8164							
B. M. 44, Holman..	150.97	N	+1.4443	—2.5	1.6	......	119.8362	......	....	P.
		S	+1.4394	+2.4	......	......	....	......	....	F.
		Mean..	+1.4418							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
U. S. P. B. M. 29 ...	151. 29	N	+11. 2023	—1. 3	0. 9	13. 0	131. 0372	+0. 2	131. 0374	P.
		S	+11. 1997	+1. 3	......	......	....	......	....	F.
		Mean..	+11. 2010							
T. B. M. 167	151. 66	S	—7. 4074	—0. 2	0. 2	......	123. 6296	......	....	F.
		S	—7. 4079	+0. 3	......	......	....	......	....	F.
		Mean..	—7. 4076							
B. M. 45, Holman..	153. 51	S	—3. 3295	+3. 3	2. 2	......	120. 3034	......	....	F.
		S	—3. 3229	—3. 3	......	......	....	......	....	F.
		Mean..	—3. 3262							
T. B. M. 170	154. 62	S	—1. 6221	—0. 4	0. 3	......	118. 6809	......	....	F.
		S	—1. 6229	+0. 4	......	......	....	......	....	F.
		Mean..	—1. 6225							
B. M. 46, Holman..	155. 18	S	+2. 8847	+1. 0	0. 7	......	121. 5666	......	....	F.
		N	+2. 8867	—1. 0	......	......	....	......	....	F.
		Mean..	+2. 8857							
T. B. M. 171	155. 91	S	—3. 0724	—0. 8	0. 5	......	118. 4934	......	....	F.
		N	—3. 0740	+0. 8	......	......	....	......	....	P.
		Mean..	—3. 0732							
*U. S. P. B. M. 30 ..	....	....	+6. 1939	—0. 4	0. 3	13. 2	124. 6869	+0. 2	124. 6871	P.
		....	+6. 1931	+0. 4	......	......	....	......	....	P.
		Mean..	+6. 1935							
B. M. 48, Holman..	158. 29	S	+1. 5794	+2. 6	1. 7	......	120. 0754	......	....	F.
		N	+1. 5846	—2. 6	......	......	....	......	....	P.
		Mean..	+1. 5820							
B. M. 50, Holman..	160. 77	S	—1. 1472	+0. 6	0. 4	......	118. 9288	......	....	F.
		N	—1. 1459	—0. 7	......	......	....	......	....	P.
		Mean..	—1. 1466							
U. S. P. B. M. 31 ...	161. 84	S	+9. 9707	+4. 6	1. 6	13. 4	128. 9041	+0. 2	128. 9043	F.
		N	+9. 9784	—3. 1	......	......	....	......	....	F.
		N	+9. 9769	—1. 6	......	......	....	......	....	P.
		Mean..	+9. 9753							
B. M. 51, Holman..	162. 14	S	—8. 9848	—0. 6	0. 4	......	119. 9187	......	....	F.
		N	—8. 9860	+0. 6	......	......	....	......	....	F.
		Mean..	—8. 9854							
T. B. M. 173	162. 48	S	—1. 5273	+0. 7	0. 5	......	118. 3921	......	....	F.
		N	—1. 5258	—0. 8	......	......	....	......	....	F.
		Mean..	—1. 5266							
T. B. M. 174	162. 75	S	—2. 7524	—1. 3	0. 9	......	115. 6384	......	....	F.
		N	—2. 7550	+1. 3	......	......	....	......	....	P.
		Mean..	—2. 7537							
T. B. M. 174½	162. 80	S	+1. 1607	+0. 1	0. 0	......	116. 7992	......	....	P.
		N	+1. 1608	0. 0	......	......	....	......	....	P.
		Mean..	+1. 1608							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
B. M. 53, Holman..	164.88	N.......	+8.7970	—1.4	1.0	......	125.5948	......	....	P.
		S	+8.7941	+1.5	......	......	....	......	....	F.
		Mean..	+8.7956							
B. M. 54, Holman..	165.88	N.......	—1.5969	+3.1	2.1	......	124.0010	......	....	P.
		S	—1.5906	—3.2	......	......	....	......	....	F.
		Mean..	—1.5938							
U. S. P. B. M. 32...	166.06	N.......	+1.1535	—0.4	0.3	13.7	125.1541	+0.2	125.1543	P.
		S	+1.1527	+0.4	......	......	....	......	....	F.
		Mean..	+1.1531							
T. B. M. 176	166.92	S	+1.0474	+0.2	0.2	......	126.2017	......	....	F.
		N.......	+1.0479	—0.3	......	......	....	......	....	P.
		Mean..	+1.0476							
*U. S. P. B. M. 33..	....	....	+2.1128	+0.4	0.3	13.7	128.3149	+0.2	128.3151	P.
			+2.1137	—0.5	......	......	....	......	....	P.
		Mean..	+2.1132							
T. B. M. 180	171.42	S	—4.6547	+5.7	3.3	......	121.5527	......	....	F.
		N.......	—4.6432	—5.8	......	......	....	......	....	P.
		Mean..	—4.6490							
U. S. P. B. M. 34...	173.86	S	+1.6958	+5.5	2.0	14.3	123.2540	+0.2	123.2542	F.
		N.......	+1.7020	—0.7	......	......	....	......	....	F.
		N.......	+1.7061	—4.8	......	......	....	......	....	P.
		Mean..	+1.7013							
T. B. M. 182	175.24	S	—0.2147	+0.7	0.3	......	123.0400	......	....	F.
		N.......	—0.2132	—0.8	......	......	....	......	....	P.
		S	—0.2141	+0.1	......	......	....	......	....	P.
		Mean..	—0.2140							
T. B. M. 183	175.74	S	+1.4162	—0.8	1.9	......	124.4554	......	....	F.
		N.......	+1.4101	+5.3	......	......	....	......	....	P.
		S	+1.4198	—4.4	......	......	....	....	....	P.
		Mean..	+1.4154							
T. B. M. 184	176.03	S	—3.3225	—0.6	0.4	......	121.1323	......	....	F.
		N.......	—3.3237	+0.6	......	......	....	......	....	P.
		Mean..	—3.3231							
T. B. M. 188	181.04	S	+2.5663	+4.3	2.9	......	123.7029	......	....	F.
		N.......	+2.5749	—4.3	......	......	....	......	....	P.
		Mean..	+2.5706							
U. S. P. B. M. 35...	181.47	S	+0.9589	—0.3	0.2	14.7	124.6615	+0.2	124.6617	F.
		N.......	+0.9583	+0.3	......	......	....	......	....	P.
		Mean..	+0.9586							
*U. S. P. B. M. 36..	....	....	+2.1172	—0.2	0.1	14.7	126.7785	+0.2	126.7787	P.
			+2.1168	+0.2	......	......	....	......	....	P.
		Mean..	+2.1170							
T. B. M. 190	181.48	S	—0.2277	+0.3	0.2	......	124.4341	......	....	F.
		N.......	—0.2271	—0.3	......	......	....	......	....	F.
		Mean..	—0.2274							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 191	182.48	S	—2.0789	+3.3	1.1		122.3585			F.
		N	—2.0742	—1.4						F.
		N	—2.0737	—1.9						F.
		Mean	—2.0756							
T. B. M. 193	183.08	S	—1.3014	+0.6	0.4		121.0577			F.
		N	—1.3003	—0.5						F.
		Mean	—1.3008							
T. B. M. 194	184.35	S	—1.3671	+4.5	1.6		119.6951			F.
		N	—1.3594	—3.2						F.
		N	—1.3613	—1.3						F.
		Mean	—1.3626							
T. B. M. 195	185.59	S	+0.7499	+1.3	0.9		120.4463			F.
		N	+0.7524	—1.2						F.
		Mean	+0.7512							
T. B. M. 196	186.97	S	—0.6202	+3.6	1.9		119.8297			F.
		N	—0.6110	—5.6						F.
		N	—0.6186	+2.0						P.
		Mean	—0.6166							
T. B. M. 197	187.89	S	—0.4995	+1.9	1.3		119.3321			F.
		N	—0.4957	—1.9						F.
		Mean	—0.4976							
* U. S. P. B. M. 87		S	—1.2216	+1.8	1.2	15.1	118.1123	+0.1	118.1124	P.
		N	—1.2181	—1.7						P.
		Mean	—1.2198							
T. B. M. 198	188.53	S	+0.3375	+0.9	0.6		119.6705			P.
		N	+0.3393	—0.9						F.
		Mean	+0.3384							
T. B. M. 203	192.87	S	+0.8977	+1.3	0.9		120.5695			P.
		N	+0.9004	—1.4						P.
		Mean	+0.8990							
T. B. M. 205	193.58	N	—6.8896	—0.5	0.3		113.6794			P.
		S	—6.8906	+0.5						P.
		Mean	—6.8901							
* T. B. M. 206 (River crossing Chester, Ill.)		S	—0.5593		1.7		113.1309			P.
		N	—0.5396							P.
		N	—0.5428	+2.5						F.
		S	—0.5521	—2.6						F.
		Mean	—0.5485							
* U. S. P. B. M. 88		S	+8.9599	—0.3	0.2	15.2	122.0905	+0.2	122.0907	F.
		N	+8.9593	+0.3						F.
		Mean	+8.9596							
* T. B. M. 207		S	—2.3348	+1.4	0 9		119.7571			F.
		N	—2.3320	—1.4						F.
		Mean	—2.3334							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
*U. S. P. B. M. 39..	....	S	+2.5103	—0.3	0.2	15.2	122.2671	+0.2	122.2673	F.
		N	+2.5096	+0.4	......	......	....	......	....	F.
		Mean..	+2.5100							
T. B. M. 208	194.69	S	+6.8116	—0.2	0.1	......	120.4908	......	....	F.
		N	+6.8118	+0.1	......	......	....	......	....	F.
		Mean..	+6.8114							
T. B. M. 209	196.91	S	—0.8889	+3.2	2.1	......	120.1051	......	....	F.
		N	—0.8795	—6.2	......	......	....	......	....	F.
		S	—0.8887	+3.0	......	......	....	......	....	F.
		Mean..	—0.8857							
T. B. M. 211	197.97	N	—0.9232	+4.1	2.7	......	119.1860	......	....	P.
		S	—0.9150	—4.1	......	......	....	......	....	P.
		Mean..	—0.9191							
T. B. M. 213	198.95	N	—0.1146	+0.6	0.4	......	119.0720	......	....	P.
		S	—0.1133	—0.7	......	......	....	......	....	P.
		Mean..	—0.1140							
T. B. M. 215	201.46	N	—1.2221	+0.5	0.3	......	117.8504	......	....	P.
		S	—1.2211	—0.5	......	......	....	......	....	F.
		Mean..	—1.2216							
*U. S. P. B. M. 40..	....	S	+0.2030	—1.6	1.1	15.6	118.0518	+0.1	118.0519	F.
		N	+0.1997	+1.7	......	......	....	......	....	F.
		Mean..	+0.2014							
T. B. M. 217	202.73	S	+1.8685	+2.6	1.7	......	119.7215	......	....	F.
		N	+1.8737	—2.6	......	......	....	......	....	F.
		Mean..	+1.8711							
T. B. M. 218	203.97	S	—1.3034	+2.4	2.1	......	118.4205	......	....	F.
		N	—1.2948	—6.2	......	......	....	......	....	F.
		S	—1.3049	+3.9	......	......	....	......	....	F.
		Mean..	—1.3010							
T. B. M. 219	204.52	S	+0.7416	+0.6	0.2	......	119.1627	......	....	F.
		N	+0.7424	—0.2	......	......	....	......	....	P.
		S	+0.7427	—0.5	......	......	....	......	....	P.
		Mean..	+0.7422							
T. B. M. 221	205.73	S	—0.3961	+3.1	1.1	......	118.7697	......	....	F.
		N	—0.3918	—1.2	......	......	....	......	....	P.
		S	—0.3910	—2.0	......	......	....	......	....	P.
		Mean..	—0.3930							
T. B. M. 223	206.93	S	—0.9955	+1.5	1.0	......	117.7757	......	....	F.
		N	—0.9924	—1.6	......	......	....	......	....	P.
		Mean..	—0.9940							
U. S. P. B. M. 41..	....	S	—1.2012	+1.4	1.3	15.9	116.5759	+0.1	116.5760	F.
		N	—1.1944	—5.4	......	......	....	......	....	F.
		S	—1.2004	+0.6	......	......	....	......	....	P.
		N	—1.2030	+3.2	......	......	....	......	....	P.
		Mean..	—1.1998							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 224	208.04	S	+0.8431	-1.3	0.9		118.6175			P.
		N	+0.8405	+1.3						P.
		Mean	+0.8418							
T. B. M. 227	210.12	S	-2.5950	+4.8	3.2		116.0273			P.
		N	-2.5855	-4.7						P.
		Mean	-2.5902							
T. B. M. 229	212.17	S	+1.2678	-2.0	1.4		117.2931			P.
		N	+1.2637	+2.1						P.
		Mean	+1.2658							
T. B. M. 232	214.53	S	-1.6425	+3.7	2.5		115.6543			F.
		N	-1.6350	-3.8						F.
		Mean	-1.6388							
T. B. M. 233	214.96	S	+1.7483	+3.8	1.8		117.4064			F.
		N	+1.7548	-2.7						F.
		N	+1.7531	-1.0						F.
		Mean	+1.7521							
T. B. M. 235	216.97	S	-0.0630	+13.4	4.9		117.3568			F.
		N	-0.0378	-11.8						F.
		N	-0.0479	- 1.7						F.
		Mean	-0.0496							
T. B. M. 236	218.02	S	-1.0710	+8.2	2.5		116.2940			F.
		N	-1.0532	-9.6						F.
		N	-1.0625	-0.3						F.
		N	-1.0644	+1.6						P.
		Mean	-1.0628							
T. B. M. 238	219.07	S	-2.1197	+3.5	2.8		114.1778			F.
		N	-2.1128	-3.4						F.
		Mean	-2.1162							
T. B. M. 239	219.99	S	-0.2346	+6.6	2.8		113.9498			F.
		N	-0.2232	-4.8						F.
		N	-0.2263	-1.7						P.
		Mean	-0.2280							
T. B. M. 240	221.10	S	+2.8857	+8.1	2.1		116.8436			F.
		N	+2.8985	-4.7						F.
		N	+2.8985	-4.7						F.
		N	+2.8923	+1.5						P.
		Mean	+2.8938							
U. S. P. B. M. 42	221.76	S	+2.5818	0.0	0.0	17.8	119.4254	+0.1	119.4255	F.
		N	+2.5817	+0.1						F.
		Mean	+2.5818							
*39 ft. mark of water-gauge at Grand Eddy, Mo.							116.3140			
T. B. M. 241	222.43	N	-1.5931	+0.2	0.1		117.8325			P.
		S	-1.5927	-0.2						P.
		Mean	-1.5929							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 245	224. 90	N	−2. 1703	−4. 1	2. 7		115. 6581			P.
		S	−2. 1784	+4. 0						P.
		Mean	−2. 1744							
T. B. M. 248	226. 59	N	+1. 5401	−1. 9	1. 2		117. 1963			P.
		S	+1. 5364	+1. 8						P.
		Mean	+1. 5382							
U. S. P. B. M. 43	227. 43	N	+1. 5780	−3. 0	1. 5	18. 1	118. 7713	+0. 1	118. 7714	P.
		S	+1. 5708	+4. 2						P.
		N	+1. 5761	−1. 1						F.
		Mean	+1. 5750							
T. B. M. 250	228. 94	S	−4. 7333	0. 0	0. 0		114. 0380			F.
		S	−4. 7333	0. 0						F. and P
		Mean	−4. 7333							
T. B. M. 251	230. 06	S	+0. 4873	−4. 2	1. 6		114. 5211			F.
		S	+0. 4790	+4. 1						F.
		N	+0. 4831	0. 0						F.
		Mean	+0. 4831							
T. B. M. 252	231. 03	S	−0. 0728	−1. 2	0. 8		114. 4471			F.
		S	−0. 0752	+1. 2						F.
		Mean	−0. 0740							
T. B. M. 254	231. 55	S	−0. 2263	+1. 9	1. 3		114. 2227			F.
		S	−0. 2225	−1. 9						F.
		Mean	−0. 2244							
U. S. B. M. 35 (Old B. M.)	235. 80	S	−5. 1887	−1. 7	1. 2	18. 3	109. 0323	0. 0	109. 0323	P.
		S	−5. 1920	+1. 6						F.
		Mean	−5. 1904							
T. B. M. 260	236. 45	S	−0. 8909	−1. 1	0. 7		108. 1403			P.
		S	−0. 8931	+1. 1						F.
		Mean	−0. 8920							
U. S. P. B. M. 44	237. 59	S	+10. 4116	−0. 8	0. 6	18. 3	118. 5511	+0. 1	118. 5512	P.
		S	+10. 4099	+0. 9						F.
		Mean	+10. 4108							
T. B. M. 262	238. 77	S	−2. 6381	+2. 5	1. 7		115. 9155			P.
		S	−2. 6331	−2. 5						F.
		Mean	−2. 6356							
T. B. M. 264	241. 04	S	−1. 3084	+2. 6	1. 7		114. 6097			P.
		S	−1. 3032	−2. 6						F.
		Mean	−1. 3058							
U. S. P. B. M. 45	242. 53	N	+1. 9860	+0. 6	0. 4	18. 4	116. 5963	+0. 1	116. 5964	F.
		S	+1. 9871	−0. 5						F.
		Mean	+1. 9866							
U. S. P. B. M. 46	242. 98	N	−0. 1241	−0. 7	0. 5	18. 5	116. 4715	+0. 1	116. 4716	F.
		S	−0. 1255	+0. 7						F.
		Mean	−0. 1248							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 266½	243. 78	N	−1. 0413	+0. 1	0. 1		115. 4303			F.
		S	−1. 0411	−0. 1						F.
		Mean	−1. 0412							
T. B. M. 267	244. 56	N	−8. 4535	+0. 4	0. 3		106. 9772			F.
		S	−8. 4527	−0. 4						F.
		Mean	−8. 4531							
T. B. M. 269	245. 87	N	+2. 5013	+14. 8	5. 0		109. 4933			F.
		S	+2. 5230	−6. 9						F.
		N	+2. 5240	−7. 9						P.
		Mean	+2. 5161							
*U. S. P. B. M. 47			+1. 5096	+0. 1	0. 1	19. 1	111. 0030	+0. 1	111. 0031	P.
			+1. 5098	−0. 1						P.
		Mean	+1. 5097							
T. B. M. 270	246. 92	N	−2. 9095	−3. 2	1. 2		106. 5806			F.
		N	−2. 9156	+2. 9						P.
		N	−2. 9130	+0. 3						F.
		Mean	−2. 9127							
T. B. M. 271	248. 26	N	+2. 0844	+0. 6	0. 4		108. 6656			F.
		N	+2. 0857	−0. 7						P.
		Mean	+2. 0850							
U. S. P. B. M. 48	252. 06	N	+1. 3694	−3. 4	2. 3	19. 8	110. 0316	+0. 1	110. 0317	F.
		N	+1. 3626	+3. 4						P.
		Mean	+1. 3660							
T. B. M. 274	252. 94	N	−3. 4783	−1. 9	1. 3		106. 5514			F.
		N	−3. 4821	+1. 9						P.
		Mean	−3. 4802							
T. B. M. 275	253. 90	N	−0. 5678	+3. 4	1. 1		105. 9870			F.
		N	−0. 5628	−1. 6						F.
		N	−0. 5627	−1. 7						P.
		Mean	−0. 5644							
T. B. M. 276	255. 06	N	+2. 8794	−0. 8	0. 5		108. 8656			F.
		N	+2. 8778	+0. 8						P.
		Mean	+2. 8786							
U. S. P. B. M. 49	256. 90	N	+1. 3358	−0. 4	0. 3	19. 4	110. 2010	+0. 1	110. 2011	F
		N	+1. 3349	+0. 5						P.
		Mean	+1. 3354							
T. B. M. 278	258. 13	S	−3. 7123	−0. 5	0. 4		106. 4882			F.
		N	−3. 7134	+0. 6						F.
		Mean	−3. 7128							
T. B. M. 283	261. 63	S	+5. 8008	+2. 3	1. 5		112. 2913			F.
		N	+5. 8054	−2. 3						P.
		Mean	+5. 8031							
T. B. M. 285	262. 30	S	−0. 0784	+2. 3	1. 1		112. 2152			F.
		N	−0. 0728	−3. 3						P.
		N	−0. 0771	+1. 0						P.
		Mean	−0. 0761							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
U. S. P. B. M. 50	264.06	S	−1.9892	−0.4	0.3	19.5	110.2256	+0.1	110.2257	F.
		N	−1.9901	+0.5						P.
		Mean	−1.9896							
T. B. M. 287	265.17	S	−3.0334	−4.6	1.7		107.1876			F.
		N	−3.0386	+0.6						F.
		N	−3.0419	+3.9						P.
		Mean	−3.0380							
T. B. M. 289	266.54	S	−0.2684	+2.6	1.7		106.9218			F.
		N	−0.2632	−2.6						F.
		Mean	−0.2658							
T. B. M. 291	268.49	S	−1.8695	−5.9	4.0		105.0464			P.
		N	−1.8814	+6.0						P.
		Mean	−1.8754							
T. B. M. 293	270.00	S	−0.7045	−3.4	1.2		104.3385			F.
		N	−0.7108	+2.9						F.
		S	−0.7084	+0.5						F.
		Mean	−0.7079							
T. B. M. 295	270.16	S	+0.7342	−0.2	0.4		105.0725			F.
		N	+0.7349	−0.9						F.
		S	+0.7329	+1.1						F.
		Mean	+0.7340							
U. S. P. B. M. 51	270.79	S	+4.0609	+0.7	0.5	20.1	109.1341	0.0	109.1341	F.
		N	+4.0624	−0.8						F.
		Mean	+4.0616							
T. B. M. 298	271.64	S	+2.6249	−0.5	0.3		111.7585			F.
		N	+2.6240	+0.4						F.
		Mean	+2.6244							
T. B. M. 300	272.68	S	+1.7980	0.0	0.0		113.5565			F.
		N	+1.7981	−0.1						F.
		Mean	+1.7980							
T. B. M. 301	273.30	S	−1.8182	−0.1	0.1		111.7382			F.
		N	−1.8184	+0.1						F.
		Mean	−1.8183							
T. B. M. 302½	274.06	S	−1.4306	−1.2	0.8		110.3064			F.
		N	−1.4329	+1.1						F.
		Mean	−1.4318							
T. B. M. 303	274.79	S	−0.2885	−4.1	1.5		110.0138			F.
		N	−0.2930	+0.4						F.
		S	−0.2963	+3.7						F.
		Mean	−0.2926							
U. S. P. B. M. 52	275.49	S	+0.5587	+1.8	1.2	20.2	110.5743	+0.1	110.5744	F.
		N	+0.5623	−1.8						F.
		Mean	+0.5605							
T. B. M. 305	276.46	S	−2.6277	+2.8	1.9		107.9494			F.
		N	−2.6221	−2.8						F.
		Mean	−2.6249							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 308	278. 04	S	+0. 8635	+0. 5	0. 3	......	108. 8134	......	....	F.
		N	+0. 8644	−0. 4	......	......	....	......	....	F.
		Mean	+0. 8640							
T. B. M. 309	279. 11	S	+0. 2051	+3. 6	1. 3	......	109. 0221	......	....	F.
		N	+0. 2117	−3. 0	......	......	....	......	....	F.
		N	+0. 2094	−0. 7	......	......	....	......	....	F.
		Mean	+0. 2087							
T. B. M. 311	279. 80	N	+1. 2971	0. 0	0. 0	......	110. 3192	......	....	F.
		S	+1. 2971	0. 0	......	......	....	......	....	F.
		Mean	+1. 2971							
T. B. M. 314	281. 89	S	−1. 6048	+1. 6	1. 1	......	108. 7160	......	....	F.
		N	−1. 6015	−1. 7	......	......	....	......	....	F.
		Mean	−1. 6032							
U. S. P. B. M. 53	285. 34	N	+0. 0515	−3. 5	2. 3	20. 5	108. 7640	0. 0	108. 7640	F.
		S	+0. 0445	+3. 5	......	......	....	......	....	F.
		Mean	+0, 0480							
T. B. M. 318	285. 61	S	+2. 5515	−0. 2	0. 1	......	111. 3153	......	....	F.
		N	+2. 5511	+0. 2	......	......	....	......	....	F.
		Mean	+2. 5513							
T. B. M. 320	286. 88	S	−0. 7217	−0. 5	0. 4	......	110. 5931	......	....	F.
		N	−0. 7228	+0. 6	......	......	....	......	....	F.
		Mean	−0. 7222							
T. B. M. 321	287. 74	S	+0. 0083	+2. 8	1. 0	......	110. 6042	......	....	F.
		N	+0. 0128	−1. 7	......	......	....	......	....	F.
		S	+0. 0123	−1. 2	......	......	....	......	....	F.
		Mean	+0. 0111							
U. S. P. B. M. 54	288. 51	S	+1. 1415	+3. 7	1. 2	20. 5	111. 7494	+0. 1	111. 7495	F
		N	+1. 1464	−1. 2	......	......	....	......	....	F.
		N	+1. 1477	−2. 5	......	......	....	......	....	F.
		Mean	+1. 1452							
*H. W. mark July, 1844.	....	....	+0. 2650	......	......	......	112. 0149	......	....	F.
			+0. 2660	......	......	......	....	......	....	F.
		Mean	+0. 2655							
U. S. P. B. M. 55	289. 41	S	+3. 0233	+0. 2	0. 1	20. 5	114. 7729	+0. 1	114. 7730	F.
		N	+3. 0237	−0. 2	......	......	....	......	....	F.
		Mean	+3. 0235							
U. S. P. B. M. 56	289. 71	S	−7. 6481	−0. 1	0. 1	20. 5	107. 1247	0. 0	107. 1247	F.
		N	−7. 6484	+0. 2	......	......	....	......	....	F.
		Mean	−7. 6482							
T. B. M. 324	291. 22	S	+2. 0458	+0. 6	0. 4	......	109. 1711	......	....	F.
		N	+2. 0471	−0. 7	......	......	....	......	....	F.
		Mean	+2. 0464							
T. B. M. 326	292. 92	N	−0. 5109	+0. 6	0. 4	......	108. 6608	......	....	F.
		S	−0. 5097	−0. 6	......	......	....	......	....	F.
		Mean	−0. 5103							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 328	294.14	N.......	—0.4683	—0.8	0.5	......	108.1917	......	....	F.
		S	—0.4699	+0.8	......	......	....	......	....	F.
		Mean ..	—0.4691							
U. S. P. B. M. 57 ...	297.49	S	+2.7111	+2.7	1.8	20.6	110.9055	+0.1	110.9056	F.
		N.......	+2.7166	—2.8	......	......	....	......	....	F.
		Mean ..	+2.7138							
T. B. M. 331½	297.86	N.......	—8.6692	+0.1	0.1	......	102.2364	......	....	F.
		S	—8.6690	—0.1	......	......	....	......	....	F.
		Mean ..	—8.6691							
*8 foot mark of upper gauge at Gray's Point, Mo.	....	....	—1.8066	......	......	......	100.4316	......	....	F.
			—1.8031	......	......	......	....	......	....	F.
		Mean ..	—1.8048							
T. B. M. 332	299.05	N.......	—1.7321	—5.0	1.9	......	100.4993	......	....	F.
		S	—1.7417	+4.6	......	......	....	......	....	F.
		S	—1.7376	+0.5	......	......	....	......	....	F.
		Mean ..	—1.7371							
U. S. B. M. 74 (Old B. M.)	299.37	S	+2.0451	+0.4	0.3	20.7	102.5448	0.0	102.5448	F.
		N.......	+2.0459	—0.4	......	......	....	......	....	F.
		Mean ..	+2.0455							
*H. W. mark, July, 1844, at Gray's Point, Mo.	....	....	+8.7797	......	......	......	111.3240	......	....	F.
			+8.7788	......	......	......	....	......	....	F.
		Mean ..	+8.7792							
T. B. M. 334	300.53	S	+5.2311	—0.7	0.4	......	107.7752	......	....	F.
		N.......	+5.2298	+0.6	......	......	....	......	....	F.
		Mean ..	+5.2304							
T. B. M. 335	301.66	S	+0.1470	—0.6	0.4	......	107.9216	......	....	F.
		N.......	+0.1458	+0.6	......	......	....	......	....	F.
		Mean ..	+0.1464							
T. B. M. 338	304.16	S	+1.7995	+1.7	1.1	......	109.7228	......	....	F.
		N.......	+1.8029	—1.7	......	......	....	......	....	F.
		Mean ..	+1.8012							
U. S. P. B. M. 58 ...	305.24	S	+0.9547	—0.3	0.2	20.8	110.6772	+0.1	110.6773	F.
		N.......	+0.9542	+0.2	......	......	....	......	....	F.
		Mean ..	+0.9544							
T. B. M. 340	306.18	N.......	—2.4323	+1.1	0.7	......	108.2460	......	....	F.
		S	—2.4301	—1.1	......	......	....	......	....	F.
		Mean ..	—2.4312							
T. B. M. 342	307.32	N.......	—0.3806	—1.1	1.1	......	107.8643	......	....	F.
		S	—0.3850	+3.3	......	......	....	......	....	F.
		N	—0.3795	—2.2	......	......	....	......	....	F.
		Mean ..	—0.3817							
T. B. M. 343	308.10	S	—3.4597	—0.2	0.1	......	104.4044	......	....	F.
		N.......	—3.4601	+0.2	......	......	....	......	....	F.
		Mean ..	—3.4599							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 345	309.06	N	−1.0015	+0.7	0.4		103.4036			F.
		S	−1.0002	−0.6						F.
		Mean	−1.0008							
*U. S. P. B. M. 59		N	+15.3483	+2.0	0.7	20.8	118.7539	+0.1	118.7540	F.
		S	+15.3515	−1.2						F.
		S	+15.3512	−0.9						F.
		Mean	+15.3503							
*U. S. P. B. M. 60		N	−8.2528	−2.0	1.3	20.9	110.5031	+0.1	110.5032	F.
		S	−8.2488	+2.0						F.
		Mean	−8.2508							
*U. S. P. B. M. 61		S	+6.1278	−0.3	0.2	20.9	116.6306	+0.1	116.6307	F.
		N	+6.1272	+0.3						F.
		Mean	+6.1275							
*H. W. mark, 1858, Commerce, Mo.							107.1321			
T. B. M. 349	309.15	N	−0.7183	+0.1	0.1		102.6854			F.
		S	−0.7180	−0.2						F.
		Mean	−0.7182							
T. B. M. 350	309.54	S	+1.5212	−0.1	1.3		104.2065			F.
		N	+1.5178	+3.3						F.
		S	+1.5243	−3.2						F.
		Mean	+1.5211							
T. B. M. 351	309.66	S	−0.4190	+2.4	0.0		103.7899			F.
		N	−0.4163	−0.3						F.
		S	−0.4159	−0.7						F.
		N	−0.4157	−0.9						F.
		S	−0.4163	−0.3						F.
		Mean	−0.4166							
T. B. M. 353	310.06	S	−0.7842	−2.9	1.0		103.0028			F.
		N	−0.7888	+1.7						F.
		S	−0.7883	+1.2						F.
		Mean	−0.7871							
T. B. M. 355	310.14	S	+5.3542	+0.5	0.3		108.3575			F.
		N	+5.3552	−0.5						F.
		Mean	+5.3547							
*U. S. P. B. M. 62		S	−3.7507	+1.0	0.7	20.9	104.6078	0.0	104.6078	F.
		N	−3.7487	−1.0						F.
		Mean	−3.7497							
*U. S. P. B. M. 63		S	+4.1882	+0.7	0.5	20.9	108.7967	0.0	108.7967	F.
		N	+4.1896	−0.7						F.
		Mean	+4.1889							
T. B. M. 357	313.07	S	−1.4364	+0.6	0.4		106.9217			F.
		N	−1.4353	−0.5						F.
		Mean	−1.4358							
T B. M. 359	314.34	S	−0.9348	−1.4	1.3		105.9855			F.
		N	−0.9400	+3.8						F
		S	−0.9339	−2.3						F.
		Mean	−0.9362							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 360	315. 72	S	+1. 6221	—0. 7	0. 5	......	107. 6069	......	....	F.
		N.	+1. 6207	+0. 7	......	......	....	......	....	F.
		Mean ..	+1. 6214							
T. B. M. 363	317. 38	S	—1. 7910	+2. 0	1. 3	......	105. 8179	......	....	F.
		N	—1. 7871	—1. 9	......	......	....	......	....	F.
		Mean ..	—1. 7890							
*U. S. P. B. M. 64 ..	....	S	+1. 7154	+8. 3	2. 3	21. 1	107. 5416	0. 0	107. 5416	P.
		N	+1. 7226	+1. 1	......	......	....	......	....	P.
		S	+1. 7284	—4. 7	......	......	....	......	....	B.
		N	+1. 7283	—4. 6	......	......	....	......	....	B.
		Mean ..	+1. 7237							
T. B. M. 368	320. 38	S	—0. 9097	—0. 1	0. 1	......	104. 9081	......	....	P.
		N	—0. 9099	+0. 1	......	......	....	......	....	P.
		Mean ..	—0. 9098							
T. B. M. 371	323 11	S	+2. 1265	—2. 5	1. 7	......	107. 0321	......	....	P.
		N	+2. 1215	+2. 5	......	......	....	......	....	F.
		Mean ..	+2. 1240							
T. B. M. 372	324. 13	S	+0. 2616	—3. 3	1. 2	......	107. 2904	......	....	P.
		N	+0. 2576	+0. 7	......	......	....	......	....	F.
		S	+0. 2556	+2. 7	......	......	....	......	....	F.
		Mean ..	+0. 2583							
T. B. M. 375	326. 37	S	—0. 7727	+1. 1	0. 7	......	106. 5188	......	....	F.
		N	—0. 7706	—1. 0	......	......	....	......	....	F.
		Mean ..	—0. 7716							
T. B. M. 377	328. 21	S	—2. 1944	+3. 3	1. 6	......	104. 3277	......	....	F.
		N	—2. 1864	—4. 7	......	......	....	......	....	F.
		N	—2. 1926	+1. 5	......	......	....	......	....	F.
		Mean ..	—2. 1911							
T. B. M. 379	329. 45	S	+0. 2664	—1. 3	0. 9	......	104. 5928	......	....	F.
		N	+0. 2638	+1. 3	......	......	....	......	....	P.
		Mean ..	+0. 2651							
T. B. M. 380	331. 68	S	—1. 1677	+0. 9	0. 6	......	103. 4260	......	....	F.
		N	—1. 1650	—0. 9	......	......	....	......	....	P.
		Mean ..	—1. 1668							
*U. S. P. B. M. 65 ..	....	S	+0. 0349	—0. 4	0. 3	21. 2	103. 4605	0. 0	103. 4605	P.
		N	—0. 0341	+0. 4	......	......	....	......	....	P.
		Mean ..	+0. 0345							
T. B. M. 382	335. 10	S	+0. 3677	+2. 9	2. 0	......	103. 7966	......	....	F.
		N	+0. 3736	—3. 0	......	......	....	......	....	P.
		Mean ..	+0. 3706							
T. B. M. 384	337. 00	S	—1. 3907	+2. 0	1. 7	......	102. 4079	......	....	P.
		N	—1. 3837	—5. 0	......	......	....	......	....	P.
		S	—1. 3918	+3. 1	......	......	....	......	....	Sn.
		Mean ..	—1. 3887							

Results of precise leveling—Continued.

GRAFTON, ILL., TO CAIRO, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 385	338. 13	S	+0. 6551	+1. 1	0. 7	......	103. 0641	......	....	P.
		N	+0. 6572	—1. 0	......	......	....	......	....	P.
		Mean ..	+0. 6562							
T. B. M. 387	339. 48	S	—0. 2534	+2. 4	1. 6	......	102. 8131	......	....	F.
		N	—0. 2486	—2. 4	......	......	....	......	....	F.
		Mean ..	—0. 2510							
T. B. M. 388	340. 51	S	—1. 2929	+3. 8	1. 6	......	101. 5240	......	....	F.
		N	—1. 2849	—4. 2	......	......	....	......	....	F.
		N	—1. 2896	+0. 5	......	......	....	......	....	F.
		Mean ..	—1. 2891							
*T. B. M. 388½	340. 97	S	+1. 0554	+0. 7	0. 5	......	102. 5801	......	....	F.
		N	+1. 0568	—0. 7	......	......	....	......	....	Sn.
		Mean ..	+1. 0561							
*U. S. P. B. M. 66 ..	341. 46	N	—1. 1030	+0. 6	0. 4	21. 5	101. 4777	0. 0	101. 4777	Sn.
		S	—1. 1019	—0. 5	......	......	....	......	....	Sn.
		Mean ..	—1. 1024							
T. B. M. 389	341. 94	S	—0. 0876	+2. 8	1. 1	......	101. 4392	......	....	F.
		N	—0. 0822	—2. 6	......	......	....	......	....	P.
		N	—0. 0845	—0. 3	......	......	....	......	....	F.
		Mean ..	—0. 0848							
T. B. M. 391	343. 07	S	—0. 7814	—8. 4	2. 9	......	100. 6494	......	....	B.
		N	—0. 7952	+5. 4	......	......	....	......	....	P.
		S	—0. 7928	+3. 0	......	......	....	......	....	B.
		Mean ..	—0. 7898							
B. M. 55 (old B. M.)	344. 64	S	+1. 2974	—1. 2	0. 8	......	101. 9456	......	....	B.
		N	+1. 2950	+1. 2	......	......	....	......	....	P.
		Mean ..	+1. 2962							
U. S. P. B. M. 2, Cairo, Ill.	344. 88	S	+1. 4601	—1. 0	0. 7	21. 7	103. 4047	0. 0	103. 4047	B.
		S	+1. 4581	+1. 0	......	......	....	......	....	B.
		Mean ..	+1. 4591							
U. S. P. B. M. 1, Cairo, Ill.	345. 23	S	—0. 4015	—2. 7	1. 8	21. 8	103. 0005	0. 0	103. 0005	B.
		S	—0. 4068	+2. 6	......	......	....	......	....	B.
		Mean ..	—0. 4042							
U. S. P. B. M. 3, Cairo, Ill.	345. 66	S	+2. 8234	+0. 7	0. 5	21. 8	105. 8246	0. 0	105. 8246	F.
		N	+2. 8248	—0. 7	......	......	....	......	....	F.
		Mean ..	+2. 8241							
45-foot mark of water gauge, Cairo, Ill.		S	—3. 4546	+0. 4	0. 8	......	102. 3704	......	....	F.
		N	—3. 4538	—0. 4	......	......	....	......	....	F.
		Mean ..	—3. 4542							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
U. S. P. B. M. 1	....	....	....	....	......	......	156.5368	+0.2	156.5370	....
* **Zero U. S. Engineer's gauge on canal, Keokuk, Iowa.**	....	S	−4.7631	−4.2	2.8	......	151.7695	......	....	J.
		N	−4.7715	+4.2	......	......	....	......	....	F.
		N	−4.9131	(†)	......	......	....	......	....	F.
		Mean	−4.7673							
* **"Canal" B. M. of Captain Stickney.**	....	S	−0.0108	−1.8	1.4	1.4	156.5242	......	....	J.
		S	−0.0103	−2.3	......	......	....	......	....	J.
		N	−0.0189	+6.3	......	......	....	......	....	F.
		N	−0.0105	−2.1	......	......	....	......	....	F.
		Mean	−0.0126							
* **P. B. M. 52 of Captain Mackenzie.**	0.31	S	+1.5121	−4.9	1.8	1.8	158.0440	......	....	J.
		S	+1.5039	+3.3	......	......	....	......	....	J.
		N	+1.5016	+5.6	......	......	....	......	....	F.
		N	+1.5118	−4.1	......	......	....	......	....	F.
		Mean	+1.5072							
U. S. P. B. M. 2	0.45	S	+0.2179	−3.3	1.8	1.8	156.7514	+0.2	156.7516	J.
		S	+0.2166	−2.0	......	......	....	......	....	J.
		N	+0.2066	+8.0	......	......	....	......	....	F.
		N	+0.2174	−2.8	......	......	....	......	....	F.
		Mean	+0.2146							
* **Zero of U. S. Signal Service gauge.**	....	S	−5.3178	+9.5	......	......	151.4431	......	....	J.
		N	−5.2988	−9.5	......	......	....	......	....	F.
		Mean	−5.3083							
U. S. P. B. M. 3	0.69	S	+4.6390	−1.0	0.4	1.8	161.3894	+0.2	161.3896	J.
		N	+4.6368	+1.2	......	......	....	......	....	F.
		S	+4.6382	−0.2	......	......	....	......	....	J.
		Mean	+4.6380							
T. B. M. 1	2.05	S	−4.2591	+0.6	1.4	......	157.1309	......	....	J.
		N	−4.2547	−3.8	......	......	....	......	....	F.
		S	−4.2616	+3.1	......	......	....	......	....	J.
		Mean	−4.2585							
T. B. M. 2	3.87	S	−0.5248	+4.3	1.5	......	156.6104	......	....	J.
		N	−0.5192	−1.3	......	......	....	......	....	F.
		S	−0.5176	−2.9	......	......	....	......	....	J.
		Mean	−0.5205							
U. S. P. B. M. 4	5.35	S	+1.8158	−2.1	0.8	2.9	158.4241	+0.2	158.4243	J.
		N	+1.8117	+2.0	......	......	....	......	....	F.
		N	+1.8135	+0.2	......	......	....	......	....	F.
		Mean	+1.8137							
T. B. M. 4	7.59	S	−2.7100	−0.2	0.1	......	155.7139	......	....	J.
		N	−2.7103	+0.1	......	......	....	......	....	F.
		Mean	−2.7102							
U. S. P. B. M. 5	9.19	S	+2.2941	+0.5	0.4	2.9	158.0085	+0.2	158.0087	J.
		N	+2.2952	−0.6	......	......	....	......	....	F.
		Mean	+2.2946							
* **P. B. M. 53 of Captain Mackenzie.**	....	S	−0.3669	0.0	0.0	2.9	157.6416	......	....	J.
		N	−0.3669	0.0	......	......	....	......	....	F.
		Mean	−0.3669							

† Rejected.

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 6	10.37	S	−2.7041	−0.1	0.0		155.3043			J.
		N	−2.7042	0.0						F.
		Mean	−2.7042							
T. B. M. 8	13.74	S	+0.0407	+2.5	1.7		155.3475			J.
		N	+0.0457	−2.5						F.
		Mean	+0.0432							
T. B. M. 9	15.68	S	−0.1265	−3.0	2.0	3.9	155.2180			J.
		N	−0.1325	+3.0						F.
		Mean	−0.1295							
T. B. M. 10	16.77	S	−0.3650	+0.4	0.2		154.8534			J.
		N	−0.3643	−0.3						F.
		Mean	−0.3646							
P. B. M. 54 of Captain Mackenzie.	19.45	S	−0.8667	−1.3	0.9	4.0	153.9854			J.
		N	−0.8694	+1.4						F.
		Mean	−0 8680							
* H. W. Apr., 1881, at Gregory Ldg.	19.80	N	+1.1620				155.1474			F.
* U. S. P. B. M. 6	19.57	S	+0.7836	−0.2	0.1	4.0	154.7688	+0.2	154.7690	F.
		N	+0.7832	+0.2						F.
		Mean	+0.7834							
T. B. M. 11	21.70	S	+0.1007	−2.6	1.7		154.0835			J.
		N	+0.0955	+2.6						F.
		Mean	+0.0981							
T. B. M. 12	24.19	S	−0.5573	+1.9	1.3		153.5243			J.
		N	−0.5611	−1.9						F.
		Mean	−0.5592							
T. B. M. 13	26.50	S	+0.0472	+0.2	0.1		153.5717			J.
		N	+0.0476	−0.2						F.
		Mean	+0.0474							
U. S. P. B. M. 7	28.13	S	+3.6614	+1.6	1.1	4.7	157.2347	+0.2	157.2349	J.
		N	+3.6646	−1.6						F.
		Mean	+3.6630							
T. B. M. 15	30.94	S	−0.3452	+2.0	1.3		156.8915			J.
		N	−0.3412	−2.0						F.
		Mean	−0.3432							
T. B. M. 16	32.21	S	−3.9274	0.0	0.0		152.9641			J.
		N	−3.9274	0.0						F.
		Mean	−3.9274							
T. B. M. 17	33.86	S	+0.8602	+0.2	0.1		153.8245			J.
		N	+0.8606	−0.2						F.
		Mean	+0.8604							
*H. W. 1844, 1½ miles above Canton, Mo.		S	−0.3000				153.5245			J.
*H. W. 1851, 1½ miles above Canton, Mo.		S	+0.3700				154.1945			J.

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 18	36.80	S	−0.8609	+2.4	1.8		152.9660			J.
		N	−0.8530	−5.5						F.
		S	−0.8595	+1.0						J.
		N	−0.8607	+2.2						F.
		Mean	−0.8585							
*U. S. P. B. M. 8	37.34	S	+3.8201	−0.7	0.5	5.1	156.7854	+0.2	156.7856	J.
		N	+3.8187	+0.7						F.
		Mean	+3.8194							
*U. S. P. B. M. 9	37.52	S	−0.2009	+0.2	0.1	5.1	156.5847	+0.2	156.5849	J.
		N	−0.2005	−0.2						F.
		Mean	−0.2007							
T. B. M. 19	38.37	S	−0.1998	−0.4	0.8		152.7658			J.
		N	−0.2006	+0.4						F.
		Mean	−0.2002							
T. B. M. 20	40.67	S	+0.3848	+0.1	0.1	5.0	153.1507			J.
		N	+0.3850	−0.1						F.
		Mean	+0.3849							
T. B. M. 21	42.46	S	−0.6062	+0.7	0.5		152.5452			J.
		N	−0.6048	−0.7						F.
		Mean	−0.6055							
U. S. P. B. M. 10	44.96	S	+1.0656	+1.1	0.7	5.1	153.6119	+0.1	153.6120	J.
		N	+1.0678	−1.1						F.
		Mean	+1.0667							
P. B. M. 56 of Captain Mackenzie.	46.88	N	−1.4532	+1.8	1.2		152.1605			F.
		S	−1.4496	−1.8						J.
		Mean	−1.4514							
*U. S. P. B. M. 11	46.98	S	+1.4188	−0.2	0.1	5.2	153.5791	+0.1	153.5792	F.
		S	+1.4184	+0.2						F.
		Mean	+1.4186							
H. W. April, 1881, at La Grange, Mo.			+0.1072	−0.2	0.2		152.2675			F.
			+0.1067	+0.3						J.
		Mean	+0.1070							
*H. W. 1851, (?) at La Grange, Mo.			+1.5075	−4.1			153.6639			F.
			+1.4903	+13.1						J.
			+1.5123	−8.9						J.
		Mean	+1.5034							
T. B. M. 23	47.89	S	−0.0617	−1.8	1.0		152.0970			J.
		N	−0.0678	+4.3						F.
		S	−0.0612	−2.3						J.
		N	−0.0632	−0.3						F.
		Mean	−0.0635							
T. B. M. 25	50.14	S	−1.7030	+0.6	0.6		150.3946			J.
		N	−1.7018	−0.6						F.
		S	−1.7046	+2.2						J.
		N	−1.7001	−2.3						F.
		Mean	−1.7024							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Kw.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 26	52.16	S	+0.8658	−0.8	0.5		151.2596			J.
		N	+0.8643	+0.7						F.
		Mean	+0.8650							
T. B. M. 27	53.72	S	+0.3691	+0.3	0.2		151.6290			J.
		N	+0.3697	−0.3						F.
		Mean	+0.3694							
T. B. M. 28	56.47	S	−0.9717	+0.1	0.0		150.6574			J.
		N	−0.9716	0.0						F.
		Mean	−0.9716							
T. B. M. 29	58.12	S	+0.0598	+1.0	0.7		150.7182			J.
		N	+0.0618	−1.0						F.
		Mean	+0.0608							
U. S. P. B. M. 12	60.57	N	+0.9949	+5.5	1.5	5.7	151.7186	+0.1	151.7187	F.
		S	+0.9997	+0.7						J.
		S	+1.0059	−5.5						J.
		N	+1.0011	−0.7						F.
		Mean	+1.0004							
*P. B. M. 57 of Capt. Mackenzie.	60.55	S	−0.1712				151.5474			J.
*P. B. M. 59 of Capt. Mackenzie.	60.57	N	−0.1725				151.5461			F.
T. B. M. 31	62.04	S	−1.0519	+0.8	0.5		150.6675			J.
		N	−1.0503	−0.8						F.
		Mean	−1.0511							
T. B. M. 32	63.81	S	+0.4306	+0.6	0.4		151.0987			J.
		N	+0.4317	−0.5						F.
		Mean	+0.4312							
T. B. M. 33	65.82	S	−1.0042	+0.4	0.3	5.7	150.0949			J.
		N	−1.0033	−0.5						F.
		Mean	−1.0038							
U. S. P. B. M. 13	67.18	S	+1.8197	−0.1	0.1		151.9145	+0.1	151.9146	J.
		N	+1.8195	+0.1						F.
		Mean	+1.8196							
T. B. M. 35	70.76	S	−2.3169	−0.4	0.3		149.5972			J.
		N	−2.3177	+0.4						F.
		Mean	−2.3173							
U. S. P. B. M. 14	71.84	S	+1.2115	−2.3	1.5	5.9	150.8064	+0.1	150.8065	J.
		N	+1.2069	+2.3						F.
		Mean	+1.2092							
T. B. M. 37	74.12	S	−1.5722	+2.8	1.9		149.2370			J.
		N	−1.5666	−2.8						F.
		Mean	−1.5694							
T. B. M. 38	75.90	S	−0.7520	−2.3	1.5		148.4827			J.
		N	−0.7566	+2.3						F.
		Mean	−0.7543							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*m.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 39	77.30	S	+0.0094	0.0	0.0	.....	148.4921	.....	.....	J.
		N	+0.0095	—0.1	.....	.....	.....	.....	.....	F.
		Mean..	+0.0094							
T. B. M. 40	79.49	S	+0.2576	—3.4	2.2	.....	148.7463	.....	.....	J.
		N	+0.2509	+3.8	.....	.....	.....	.....	.....	F.
		Mean..	+0.2542							
U. S. P. B. M. 15	80.98	S	+1.0065	—2.1	1.4	6.9	149.7507	+0.1	149.7508	J.
		N	+1.0023	+2.1	.....	.....	.....	.....	.....	F.
		Mean..	+1.0044							
T. B. M. 44	84.18	S	—0.2368	+0.2	0.1	.....	149.5141	.....	.....	J.
		N	—0.2365	—0.1	.....	.....	.....	.....	.....	F.
		Mean..	—0.2366							
T. B. M. 47	86.95	S	—0.7815	+1.3	0.9	.....	148.7339	.....	.....	J.
		N	—0.7788	—1.4	.....	.....	.....	.....	.....	F.
		Mean..	—0.7802							
*U. S. P. B. M. 16	88.97	S	+6.5296	+1.4	0.9	7.0	155.2649	+0.2	155.2651	J.
		N	+6.5323	—1.3	.....	.....	.....	.....	.....	F.
		Mean..	+6.5310							
T. B. M. 48	88.90	S	+4.0618	+1.1	0.7	.....	152.7968	.....	.....	J.
		N	+4.0640	—1.1	.....	.....	.....	.....	.....	F.
		Mean..	+4.0629							
*P. B. M. 58 of Capt. Mackenzie.	88.90	S	+0.0037	—0.1	0.1	7.0	152.8004	.....	.....	J.
		N	+0.0034	+0.2	.....	.....	.....	.....	.....	F.
		Mean..	+0.0036							
*H. W. 1881, at Hannibal Bridge.	88.90	.....	—3.8321	.....	.....	.....	148.9647	.....	.....	F.
*Zero of upper gauge at Hannibal Bridge.	89.13	.....	—9.6481	.....	.....	.....	143.1487	.....	.....	F.
*Zero of gauge on draw pier of Hannibal Bridge.	89.13	.....	—9.6261	.....	.....	.....	143.1707	.....	.....	F.
T. B. M. 49	90.86	S	—4.4287	+2.1	1.0	.....	148.3660	.....	.....	J.
		N	—4.4338	+3.0	.....	.....	.....	.....	.....	F.
		S	—4.4299	—0.9	.....	.....	.....	.....	.....	J.
		Mean..	—4.4308							
*H. W., 1851, at Hannibal, Mo.	90.20	S	+1.3548	+2.8	1.9	.....	149.7236	.....	.....	J.
		N	+1.3605	—2.9	.....	.....	.....	.....	.....	F.
		Mean..	+1.3576							
*H. W., 1881, at Hannibal, Mo.	90.25	.....	+0.5584	.....	.....	.....	148.9244	.....	.....	J.
U. S. P. B. M. 17	92.51	S	—0.5664	+1.2	0.8	7.1	147.8008	+0.1	147.8009	J.
		N	—0.5640	—1.2	.....	.....	.....	.....	.....	F.
		Mean.	—0.5652							
T. B. M. 52	94.81	S	+0.1685	+1.9	1.3	.....	147.9712	.....	.....	J.
		N	+0.1724	—2.0	.....	.....	.....	.....	.....	F.
		Mean..	+0.1704							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 54	97.53	S	—0.5377	+0.9	0.6		147.4344			J.
		N	—0.5359	—0.9						F.
		Mean	—0.5368							
T. B. M. 56	100.73	S	—0.9690	—0.4	0.3		146.4650			J.
		N	—0.9698	+0.4						F.
		Mean	—0.9694							
U. S. P. B. M. 18	102.04	S	+0.9168	—1.8	1.2	7.4	147.3800	+0.1	147.3801	J.
		N	+0.9131	+1.9						F.
		Mean	+0.9150							
T. B. M. 59	104.69	S	—0.0033	—1.7	1.1		147.3750			J.
		N	—0.0067	+1.7						F.
		Mean	—0.0050							
T. B. M. 60	106.33	S	+0.1227	(†)	0.4		147.5083			J.
		N	+0.1339	—0.6						F.
		S	+0.1322	+1.1						J.
		N	+0.1339	—0.6						F.
		Mean	+0.1333							
T. B. M. 63	108.41	S	—0.0055	+3.3	2.2		147.5061			J.
		N	+0.0012	—3.4						F.
		Mean	—0.0022							
T. B. M. 64	109.73	S	—0.0031	+0.4	1.2		147.5034			J.
		N	+0.0032	—5.9						F.
		S	—0.0042	+1.5						Sn.
		N	—0.0072	+4.5						R.
		N	—0.0020	—0.7						F.
		Mean	—0.0027							
*U. S. P. B. M. 19	110.65	S	+4.2446	+1.6	1.1	7.9	151.7496	+0.1	151.7497	J.
		N	+4.2479	—1.7						F.
		Mean	+4.2462							
T. B. M. 65	110.48	S	+0.6272	+1.0	0.6		148.1316			J.
		N	+0.6291	—0.9						F.
		Mean	+0.6282							
T. B. M. 66	112.86	S	—2.0781	+0.1	0.1		146.0536			J.
		N	—2.0779	—0.1						F.
		Mean	—2.0780							
T. B. M. 67	115.61	S	+4.1836	—1.1	0.7		150.2361			J.
		N	+4.1814	+1.1						F.
		Mean	+4.1825							
*U. S. P. B. M. 20	115.78	S	+0.3403	—0.3	0.2	7.9	150.5761	+0.1	150.5762	J.
		N	+0.3396	+0.4						F.
		Mean	+0.3400							
T. B. M. 68	116.38	S	—0.8351	—1.4	0.9		149.3996			J.
		N	—0.8379	+1.4						F.
		Mean	—0.8365							

† Rejected.

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 70	119.02	S	−4.1408	−4.8	1.8		145.2540			J.
		N	−4.1502	+4.6						F.
		S	−4.1458	+0.2						J.
		Mean	−4.1456							
T. B. M. 78	122.29	S	+1.3659	−0.9	0.6		146.6190			J,
		N	+1.3640	+1.0						F.
		Mean	+1.3650							
*U. S. P. B. M. 21	122.60	S	−1.4127	−0.9	0.6	8.2	145.2054	+0.1	145.2055	J.
		N	−1.4145	+0.9						F.
		Mean	−1.4136							
T. B. M. 75	126.51	S	−1.2050	+1.0	0.7		145.4150			J.
		N	−1.2030	−1.0						F.
		Mean	−1.2040							
T. B. M. 78	129.02	S	+2.6030	−0.8	0.6		148.0172			J.
		N	+2.6013	+0.9						F.
		Mean	+2.6022							
*U. S. P. B. M. 22	129.04	S	+0.9630			8.2	148.9802	+0.1	148.9803	J.
T. B. M. 79	130.26	S	+0.2989	−0.7	0.5		148.3154			J.
		N	+0.2974	+0.8						F.
		Mean	+0.2982							
U. S. P. B. M. 23	132.30	S	+0.6582	−1.8	1.2	8.3	148.9718	+0.1	148.9719	J.
		N	+0.6547	+1.7						F.
		Mean	+0.6564							
*P. B. M. 61, Mackenzie.	131.39	S	−1.9095	+1.0	0.7	8.4	147.0683			J.
		N	+1.9075	−1.0						F.
		Mean	−1.9085							
*H. W. 1851, at Louisiana, Mo.	131.86	N	−2.8545				146.1173			F.
*H. W. 1880, at Louisiana, Mo.	132.26	N	−4.3271				144.6447			F.
*H. W. 1881 (April), Louisiana, Mo.	132.26	N	−4.0681				144,9037			F.
U. S. P. B. M. 24	133.74	S	−0.2803	−0.9	0.6	8.4	148.6906	+0.1	148.6907	J.
		N	−0.2821	+0.9						F.
		Mean	−0.2812							
*H. W. 1881 (April) Louisiana, Mo.	132.42	N	−4.0285				144.9433			F.
*H. W. 1880, Louisiana, Mo.	132.42	N	−4.3252				144.6466			F.
*H. W., April 26, 1881, Louisiana, Mo.		N	−4.0678				144.6228			F.
*Zero of gauge on bridge at Louisiana, Mo.	134.05		−9.2708	−11.4	5.7		139.4312			F.
			−9.2537	+5.7						J.
		Mean	−9.2594							
T. B. M. 82	136.00	S	−3.9939	+0.3	0.2		144.6970			J.
		N	−3.9934	−0.2						F.
		Mean	−3.9936							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 86	138.59	S	+3.1569	—1.6	1.1	......	147.8523	......	....	J.
		N.......	+3.1537	+1.6	......	......	....	......	....	F.
		Mean..	+3.1553							
U. S. P. B. M. 25 ...	140.02	S	—0.5688	—0.8	0.6	......	147.2827	+0.1	147.2828	J.
		N.......	—0.5705	+0.9	......	......	....	......	....	F.
		Mean..	— 0.5696							
T. B. M. 87	141.07	S	—1.3650	+0.4	0.2	......	145.9181	......	....	J.
		N.......	—1.3643	—0.3	......	......	....	......	....	F.
		Mean..	—1.3646							
T. B. M. 88	142.29	S	+0.0446	—5.0	1.2	......	145.9577	......	....	J.
		N.......	+0.0376	+2.0	......	......	....	......	....	F.
		S	+0.0394	+0.2	......	......	....	......	....	J.
		N.......	+0.0366	+3.0	......	......	....	......	....	F.
		Mean..	+0.0396							
*U. S. P. B. M. 26 ..	143.64	S	+0.6903	—0.9	0.6	3.6	146.6471	+0.1	146.6472	J.
		N.......	+0.6884	+1.0	......	......	....	......	....	F.
		Mean..	+0.6894							
T. B. M. 89	144.08	S	—2.3480	—1.6	1.1	......	143.6081	......	....	J.
		N.......	—2.3512	+1.6	......	......	....	......	....	F.
		Mean..	—2.3496							
T. B. M. 91	145.68	S	—0.6939	—1.1	0.7	......	142.9131	......	....	J.
		N.......	—0.6960	+1.0	......	......	....	......	....	F.
		Mean..	—0.6950							
T. B. M. 92	147.02	S	+0.0963	—1.8	1.2	......	143.0076	......	....	J.
		N.......	+0.0927	+1.8	......	......	....	......	....	F.
		Mean..	+0.0945							
T. B. M. 94	147.95	S	+4.4392	—2.3	0.7	......	147.4445	......	....	J.
		N	+4.4346	+2.3	......	......	....	......	....	F.
		S	+4.4360	+0.9	......	......	....	......	....	J.
		N.......	+4.4379	—1.0	......	.....	....	......	....	F.
		Mean..	+4.4369							
*U. S. P. B. M. 27 ..	148.07	S	+0.5737	0.0	0.0	3.8	148.0182	+0.1	148.0183	J.
		N.......	+0.5737	0.0	......	......	....	......	....	F.
		Mean..	+0.5737							
T. B. M. 95	148.93	S	—1.0499	+0.1	0.1	......	146.3947	......	....	J.
		N.......	—1.0497	—0.1	......	......	....	......	....	F.
		Mean..	—1.0498							
*U. S. P. B. M. 28 ..	149.07	S	+0.1658	+0.4	0.3	3.8	146.5609	+0.1	146.5610	J.
		N.......	+0.1666	—0.4	......	......	....	......	....	F.
		Mean..	+0.1662							
*H. W. 1876, Clarksville, Mo.	149.15	N.......	—3.4025	......	......	......	142.9822	......	....	F.
*H. W. 1851, Clarksville, Mo.	149.13	S	—1.5284	......	......	......	144.8663	......	....	J.
Rod station 1, Clarksville, Mo.	148.98	S	—3.7384	—0.4	0.3	......	142.6559	......	....	J.
		N.......	—3.7392	+0.4	......	......	....	......	....	F.
		Mean..	—3.7388							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
Rod station 2, Island 463.	149.58	....	+0.0771	—0.5	0.3	......	142.7825	......	....	J.
		....	+0.0762	+0.4	......	......	....	......	....	F.
		Mean..	+0.0766							
Rod station 3	149.80	S	+0.0777	—0.5	0.3	......	142.8097	......	....	J.
		N.......	+0.0768	+0.4	......	......	....	......	....	F.
		Mean..	+0.0772							
Rod station 4	150.46	....	—0.7212	+1.1	0.7	......	142.0896	......	....	J.
		....	—0.7190	—1.1	......	......	....	......	....	F.
		Mean..	—0.7201							
Rod station 5......	150.73	....	+0.8106	+1.0	0.7	......	142.9012	......	....	J.
		....	+0.8126	—1.0	......	......	....	......	....	F.
		Mean..	+0.8116							
*U. S. P. B. M. 29 ..	150.83	S	—0.0161	—0.7	0.5	8.8	142.8844	+0.0	142.8844	J.
		N.......	—0.0175	+0.7	......	......	....	......	....	F.
		Mean..	—0.0168							
T. B. M. 97	152.75	S	—0.2629	+0.9	0.6	......	142.6392	......	....	J.
		N.......	—0.2612	—0.8	......	......	....	......	....	F.
		Mean..	—0.2620							
T. B. M. 99	155.15	S........	+ 1.2087	0.0	0.0	......	143.8479	......	....	J.
		N	+ 1.2087	0.0	......	......	....	......	....	F.
		Mean..	+ 1.2087							
*U. S. P. B. M. 30 ..	155.60	S........	— 0.9795	—0.3	0.2	8.8	142.8681	0.0	142.8681	J.
		N	— 0.9801	+0.3	......	......	....	......	....	F.
		Mean..	— 0.9798							
T. B. M. 101	157.80	S.......	— 2.2617	—2.4	1.6	......	141.5838	......	....	J.
		N	— 2.2665	+2.4	......	......	....	......	....	F.
		Mean..	— 2.2641							
T. B. M. 102	159.76	S	+ 1.2668	—0.8	0.6	......	142.8498	......	....	J.
		N	+ 1.2651	+0.9	......	......	....	......	....	F.
		Mean..	+ 1.2660							
U. S. P. B. M. 31 ...	161.18	S........	— 0.8392	—0.4	0.2	9.0	142.0102	0.0	142.0102	J.
		N	— 0.8399	+0.3	......	......	....	......	....	F.
		Mean..	— 0.8396							
T. B. M. 104	162.18	S........	— 0.9919	—0.9	0.6	......	141.0174	......	....	J.
		N	— 0.9936	+0.8	......	......	....	......	....	F.
		Mean..	— 0.9928							
T. B. M. 106	165.62	S.......	+ 0.3240	+2.1	1.4	......	141.3435	......	....	J.
		N	+ 0.3282	—2.1	......	......	....	......	....	F.
		Mean..	+ 0.3261							
U. S P. B. M. 32 ...	165.96	S........	+ 7.2578	—1.4	0.9	9.2	148.5999	+0.1	148.6000	J.
		N	+ 7.2551	+1.3	......	......	....	......	....	F.
		Mean..	+ 7.2564							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm,*	*M.*	
T. B. M. 108	167.64	S	— 7.8388	—0.1	0.1		140.7610			J.
		N	— 7.8390	+0.1						F.
		Mean	— 7.8389							
T. B. M. 109	168.93	S	+ 2.4512	—3.2	1.1		143.2090			J.
		N	+ 2.4455	+2.5						F.
		S	+ 2.4474	+0.6						J.
		Mean	+ 2.4480							
U. S. P. B. M. 33	170.24	S	+19.8283	—0.3	0.2	9.2	163.0370	+0.2	163.0372	J.
		N	+19.8277	+0.3						F.
		Mean	+19.8280							
T. B. M. 111	171.62	S	—21.3869	—0.1	0.0		141.6500			J.
		N	—21.3870	0.0						F.
		Mean	—21.3870							
T. B. M. 113	174.58	S	— 1.3173	+1.3	0.8		140.3340			J.
		N	— 1.3148	—1.2						F.
		Mean	— 1.3160							
T. B. M. 114	175.74	S	+ 2.9823	—1.7	1.1		143.3146			J.
		N	+ 2.9789	+1.7						F.
		Mean	+ 2.9806							
*H. W., 1876, at Hamburg, Ill.	175.08	S	— 2.0993				141.2153			J.
*H. W., April, 1881, at Hamburg, Ill.	175.08	S	— 2.3136				141.0010			J.
*U. S. P. B. M. 34	175.84	S	— 1.6244	+0.8	0.5	9.4	141.6910	0.0	141.6910	J.
		N	— 1.6228	—0.8						F.
		Mean	— 1.6236							
T. B. M. 115	176.76	S	+ 4.9698	—1.0	0.7		148.2834			J.
		N	+ 4.9677	+1.1						F.
		Mean	+ 4.9688							
T. B. M. 116	177.85	S	— 9.8379	+1.8	1.2		138.4473			J.
		N	— 9.8343	—1.8						F.
		Mean	— 9.8361							
U. S. P. B. M. 35	180.63	S	+ 1.4701	—2.3	1.6	9.6	139.9151	0.0	139.9151	J.
		N	+ 1.4654	+2.4						F.
		Mean	+ 1.4678							
T. B. M. 119	181.60	S	+ 0.4750	—0.8	0.6		140.3893			J.
		N	+ 0.4724	+1.8						F.
		N	+ 0.4751	—0.9						F.
		Mean	+ 0.4742							
U. S. P. B. M. 36	182.96	S	— 0.7301	+1.2	0.8	9.6	139.6604	0.0	139.6604	J.
		N	— 0.7277	—1.2						F.
		Mean	— 0.7289							
T. B. M. 123	186.24	S	— 1.0281	—1.1	0.7		138.6312			J.
		N	— 1.0303	+1.1						F.
		Mean	— 1.0292							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r,	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 124	187. 26	S.........	+ 0. 6818	—4. 4	1. 0	......	139. 3086	......	....	J.
		N	+ 0. 6753	+2. 1	......	......	....	......	....	F.
		S.........	+ 0. 6767	+0. 7	......	......	....	......	....	J.
		N	+ 0. 6760	+1. 4	......	......	....	......	....	F.
		Mean..	+ 0. 6774							
U. S. P. B. M. 37 ...	187. 92	S.........	+ 0. 2593	+0. 9	0. 6	9. 7	139. 5688	0. 0	139. 5688	F.
		N	+ 0. 2612	—1. 0	......	......	....	......	....	F.
		Mean..	+ 0. 2602							
T. B. M. 125	189. 28	S.........	— 1. 1051	—2. 5	1. 7	......	138. 4612	......	....	J.
		N	— 1. 1102	+2. 6	......	......	....	......	....	F.
		Mean..	— 1. 1076							
T. B. M. 126	189. 99	S.........	— 0. 1387	+0. 5	0. 3	......	138. 3230	......	....	J.
		N	— 0. 1377	—0. 5	......	......	....	......	....	F.
		Mean..	— 0. 1382							
T. B. M. 127	191. 95	S.........	— 0. 4808	—0. 6	0. 4	......	137. 8416	......	....	J.
		N	— 0. 4820	+0. 6	......	......	....	......	....	F.
		Mean..	— 0. 4814							
T. B. M. 128	192. 72	S.........	+ 5. 7191	—0. 2	0. 1	......	143. 5605	......	....	J.
		N	+ 5. 7187	+0. 2	......	......	....	......	....	F.
		Mean..	+ 5. 7189							
T. B. M. 129	194. 10	S	— 5. 2789	+0. 1	0. 1	......	138. 2817	......	....	J.
		N	— 5. 2786	—0. 2	......	......	....	......	....	F.
		Mean..	— 5. 2788							
U. S. P. B. M. 38 ...	195. 45	S	+ 0. 4248	+0. 4	0. 3	9. 9	138. 7069	0. 0	138. 7069	J.
		N	+ 0. 4256	—0. 4	......	......	....	......	....	F.
		Mean..	+ 0. 4252							
T. B. M. 130	196. 95	S.........	+ 0. 2804	—2. 2	1. 5	......	138. 9851	......	....	J.
		N	+ 0 2760	+2. 2	......	......	....	......	....	F.
		Mean..	+ 0. 2782							
*U. S. P. B. M. 39 ..	196. 97	S.........	+ 0. 5897	—0. 1	0. 1	10. 0	139. 5747	0. 0	139. 5747	J.
		N	+ 0. 5895	+0. 1	......	......	....	......	....	F.
		Mean..	+ 0. 5896							
T. B. M. 131	197. 93	S	+ 0. 8111	—1. 3	0. 9	......	139. 7949	......	....	J.
		N	+ 0. 8084	+1. 3	......	......	....	......	....	F.
		Mean..	+ 0. 8098							
T. B. M. 132	200. 00	S.........	— 1. 1569	+0. 3	0. 2	......	138. 6383	......	....	J.
		N	— 1. 1562	—0. 4	......	......	....	......	....	F.
		Mean..	— 1. 1566							
U. S. P. B. M. 40 ...	200. 51	S.........	— 0. 0020	—1. 2	0. 8	10. 1	138. 6351	0. 0	138. 6351	J.
		N	— 0. 0043	+1. 1	......	......	....	......	....	F.
		Mean..	— 0. 0032							
T. B. M. 133	201. 87	S.........	— 0. 6435	+0. 9	0. 6	......	137. 9925	......	....	J.
		N	— 0. 6417	—0. 9	......	......	....	......	....	F.
		Mean..	— 0. 6426							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 135	204.91	S	− 0.8927	−1.5	1.0		137.0983			J.
		N	− 0.8956	+1.4						F.
		Mean	− 0.8942							
T. B. M. 136	205.92	S	+ 4.2970	−4.8	1.1		141.3905			J.
		N	+ 4.2900	+2.2						F.
		N	+ 4.2903	+1.9						F.
		S	+ 4.2913	+0.9						J.
		Mean	+ 4.2922							
*U. S. P. B. M. 41	205.04	S	+ 0.5742	+0.4	0.8	10.2	141.9651	0.0	141.9651	J.
		N	+ 0.5750	−0.4						F.
		Mean	+ 0.5746							
T. B. M. 137	206.74	S	− 6.8958	−0.1	0.1		134.4946			J.
		N	− 6.8960	+0.1						F.
		Mean	− 6.8959							
T. B. M. 138	207.62	S	+ 4.2674	−2.9	1.0		138.7591			J.
		N	+ 4.2629	+1.6						F.
		S	+ 4.2631	+1.4						J.
		Mean	+ 4.2645							
T. B. M. 139	209.24	S	− 1.4816	+1.2	0.8		137.2787			J.
		N	− 1.4792	−1.2						F.
		Mean	− 1.4804							
T. B. M. 140	209.93	S	−2.5327	−3.9	0.9		134.7421			J.
		N	−2.5376	+1.0						F.
		S	−2.5381	+1.5						J.
		N	−2.5382	+1.6						F.
		Mean	−2.5366							
*U. S. P. B. M. 42	210.09	S	+6.3438	+0.4	0.3	10.8	141.0863	0.0	141.0863	F.
		N	+6.3446	−0.4						F.
		Mean	+6.3442							
T. B. M. 141	211.52	S	+0.1215	−3.8	1.2		134.8598			J.
		N	+0.1133	+4.4						F.
		S	+0.1187	−1.0						J.
		N	+0.1174	+0.3						F.
		Mean	+0.1177							
T. B. M. 141½	212.41	S	−0.8184	−3.3	0.8		134.0381			J.
		N	−0.8234	+1.7						F.
		N	−0.8229	+1.2						J.
		S	−0.8220	+0.3						J.
		Mean	−0.8217							
T. B. M. 143	214.52	S	+3.3567	−1.7	1.1		137.3931			J.
		N	+3.3534	+1.6						F.
		Mean	+3.3550							
*U. S. P. B. M. 43	214.53	S	+1.5071	+0.1	0.0	10.5	138.9003	0.0	138.9003	J.
		N	+1.5072	0.0						F.
		Mean	+1.5072							

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 145	217.02	S........	—3.7711	—0.5	0.3	......	133.6215	......	....	J.
		N	—3.7721	+0.5	......	.....	....	......	....	F.
		Mean..	—3.7716							
T. B. M. 146	217.53	S........	+2.6297	—0.1	0.1	......	136.2511	......	....	J.
		N	+2.6294	+0.2	......	......	....	......	....	F.
		Mean..	+2.6296							
*U. S. P. B. M. 44 ..	217.54	S........	+2.5244	0.0	0.0	10.5	138.7755	0.0	138.7755	J.
		N	+2.5245	0.1	......	......	....	......	....	F.
		Mean..	+2.5244							
T. B. M. 148	219.65	S........	—0.2916	0.0	0.0	......	135.9595	......	....	J.
		N	—0.2915	—0.1	......	......	....	.....	....	F.
		Mean..	—0.2916							
T. B. M. 150	222.15	S........	—0.3725	—0.7	0.4	......	135.5863	......	....	J.
		N	—0.3738	+0.6	......	......		......	....	F.
		Mean..	—0.3732							
T. B. M. 151	222.48	S........	—0.1989	—0.3	0.2	......	135.3871	......	....	J.
		N	—0.1995	+0.3	......	......	....	......	....	F.
		Mean..	—0.1992							
*U. S. P. B. M. 45 ..	222.49	S.......	+1.6279	—0.1	0.0	10.5	137.0149	0.0	137.0149	J.
		N	+1.6278	0.0	......	......	....	......	....	F.
		Mean..	+1.6278							
T. B. M. 152	224.47	S........	—0.2608	+0.8	0.6	......	135.1271	......	....	J.
		N	—0.2591	—0.9	......	......	....	......	....	F.
		Mean..	—0.2600							
T. B. M. 153	226.85	S........	—1.8797	+2.3	1.5	......	133.2497	......	....	J.
		N	—1.8751	—2.3	......	......	....	......	....	F.
		Mean..	—1.8774							
*U. S. P. B. M. 46 ..	226.84	S........	+11.4218	—0.1	0.1	10.6	144.6714	+01.	144.6715	J.
		N	+11.4216	+0.1	......	......	....	......	....	J.
		Mean..	+11.4217							
T. B. M. 155	229.14	S........	+0.6094	—1.0	0.7	......	133.8581	......	....	J.
		N	+0.6074	+1.0	......	......	....	......	....	F.
		Mean..	+0.6084							
T. B. M. 156	230.23	S........	+3.5679	+2.1	1.4	......	137.4281	......	....	J.
		N	+3.5720	—2.0	......	......	....	......	....	F.
		Mean..	+3.5700							
*U. S. P. B. M. 47 ..	230.24	S........	+0.4071	+0.3	0.2	10.7	137.8355	0.0	137.8355	J.
		N	+0.4078	—0.4	......	......	....	......	....	F.
		Mean..	+0.4074							
T. B. M. 157	231.82	S........	—1.1733	—2.9	1.9	......	136.2519	......	....	J.
		N	—1.1791	+2.9	......	......	....	......	....	F.
		Mean..	—1.1763							
*H. W., spring of 1881.	231.89	....	—0.6074	......	......	......	135.6445	......	....	F.

Results of precise leveling—Continued.

KEOKUK, IOWA, TO GRAFTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*	
T. B. M. 158	233.88	S.	—0.6612	+2.0	1.3	......	135.5927	......	....	J.
		N.	—0.6572	—2.0	......	......	....	......	....	F.
		Mean..	—0.6592							
T. B. M. 160	236.10	S.	+0.8102	—0.2	0.2	......	136.4027	......	....	J.
		N.	+0.8097	+0.3	......	......	....	......	....	F.
		Mean..	+0.8100							
T. B. M. 161	237.21	S.	—2.6801	+0.7	0.5	......	133.7233	......	....	J.
		N.	—2.6786	—0.8	......	......	....	......	....	R.
		Mean..	—1.6794							
U. S. P. B. M. 1 (Grafton).	239.39	S.	+0.7773	+2.9	2.0	11.2	134.5035	0.0	134.5035	J.
		N.	+0.7832	—3.0	......	......	....	......	....	F.
		Mean..	+0.7802							
Rod Station 1	239.49	S.	—3.5792	—0.6	0.3	......	130.9237	......	....	J.
		N.	—3.5806	+0.8	......	......	....	......	....	F.
		S.	—3.5787	—1.1	......	......	....	......	....	R.
		N.	—3.5808	+1.0	......	......	....	......	....	R.
		Mean..	—3.5798							
Rod Station 2 (crossing Illinois River).	239.85	S.	+0.0927	—4.3	2.7	......	131.0121	......	....	J.
		N.	+0.0828	+5.6	......	......	....	......	....	J.
		N.	+0.0806	+7.8	......	......	....	......	....	F.
		S.	+0.0976	—9.2	......	......	....	......	....	F.
		Mean..	+0.0884							
U. S. P. B. M. 2 (Grafton).	240.03	S.	+5.3498	+0.1	0.1	11.5	136.3620	0.0	136.3620	J.
		N.	+5.3500	—0.1	......	......	....	......	....	R.
		Mean..	+5.3499							
*H. W., April, 1881	241.36	....	—0.0425	......	......	......	136.3195	......	....	F.
U. S. P. B. M. 3 (Grafton).	242.17	S.	+2.9502	—0.6	0.4	11.5	....	......	†139.3116	F.
		N.	+2.9491	+0.5	......	......	....	......	....	R.
		Mean..	+2.9496							
*P.B.M.66 of Captain Mackenzie. Referred to Mackenzie B. M.	....	S.	—4.7040	+0.2	0.2	......	134.7258	......	....	F.
		N.	—4.7035	—0.3	......	......	....	......	....	F.
		Mean..	—4.7038							

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*Elevation, Mackenzie B. M., 139.4296. See page —.

†The elevation of U. S. P. B. M. 3, as given on page —, is taken as the initial elevation for all points north of Grafton. This bench-mark is on the Catholic church steps, and is believed to be more likely to have remained undisturbed than U. S. P. B. M.'s 1 and 2, which are stone posts set in the ground. The discrepancy between the determinations of difference of elevations of U. S. P. B. M. 1 and 3, made in 1880 and 1881, is 6.6mm, that of 1881 being the larger.

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.

[Bench-marks marked with an asterisk are not in the main line.]

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Mm.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
U. S. P. B. M. 3, Keokuk.									161.3901		
U. S. P. B. M. 2, Keokuk.		N	−4.6375	−0.1	0.1				156.7525	F.	J.
		S	−4.6377	+0.1						F.	F.
		Mean	−4.6376								
U. S. P. B. M. 1, Keokuk.	0.0	N	−0.2159	+0.4	0.3	0.3			156.5370 (See report 848.)	F.	J.
		S	−0.2151	−0.4						F.	F.
		Mean	−0.2155								
T. B. M. 1	1.70	N	+1.7737	−4.0	1.2		158.3147			F.	F.
		S	+1.7826	−4.9						F.	F.
		N	+1.7767	+1.0						P.	F.
		S	+1.7778	−0.1						P.	F.
		Mean	+1.7777								
T. B. M. 2	2.11	N	−0.0917	−2.5	0.7		158.2205			P.	J.
		N	−0.0941	−0.1						F.	J.
		S	−0.0944	+0.2						P.	J.
		S	−0.0968	+2.6						F.	J.
		Mean	−0.0942								
U. S. P. B. M. 1	3.68	N	+0.7318	+1.3	0.4	1.5	158.9536	+0.1	158.9537	P.	J.
		N	+0.7330	+0.1						F.	J.
		S	+0.7344	−1.3						P.	J.
		S	+0.7334	−0.3						F.	J.
		Mean	+0.7331								
*△ Northbase (Eisenmann's).	4.18	N	+0.1386		0.0		159.0922	+0.1	159.0923	F.	J.
T. B. M. 3	6.07	N	+1.5766	+1.1	0.7		160.5313			P.	J.
		N	+1.5766	+1.1						F.	J.
		S	+1.5768	+0.9						P.	J.
		S	+1.5810	−3.3						F.	J.
		Mean	+1.5777								
T. B. M. 5 and 5*a*	7.66	N	−1.1219	−0.8	0.8		159.4086			F.	F.
		S	−1.1262	+3.5						F.	F.
		N	−1.1210	−1.7						P.	F.
		S	−1.1216	−1.1						P.	F.
		Mean	−1.1227								
T. B. M. 6	8.90	N	+1.6953	0.0	0.0		161.1039			P.	F.
		S	+1.6952	+0.1						P.	F.
		Mean	+1.6953								
T. B. M. 7	10.57	N	+3.3322	+1.4	1.0		164.4375			P.	J.
		S	+3.3351	−1.5						P.	J.
		Mean	+3.3336								
T. B. M. 8	11.76	N	−1.1855	+0.1	0.1		163.2521			P.	J.
		S	−1.1853	−0.1						P.	J.
		Mean	−1.1854								
U. S. P. B. M. 2	12.20	N	−2.3647	+1.8	1.2	2.4	160.8892	+0.1	160.8893	P.	J.
		S	−2.3612	−1.7						P.	J.
		Mean	−2.3629								
T. P. B. 9 and 9*a*	13.93	N	+4.6463	+0.6	0.4		165.5361			P.	F.
		S	+4.6476	−0.7						P.	F.
		Mean	+4.6469								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T. B. M. 10	15.51	N	+0.7553	—0.9	0.6		166.2905			P.	F.
		S	+0.7534	+1.0						P.	F.
		Mean	+0.7544								
* Mechanics Rock	16.01	N	—7.2410				159.0495			P.	J. F.
T. B. M. 11	17.72	N	—3.8415	+1.3	1.0		162.4503			P.	J.
		S	—3.8361	—4.1						P.	J.
		N	—3.8407	+0.5						P.	J.
		N	—3.8425	+2.3						F.	J.
		Mean	—3.8402								
* U. S. P. B. M. 3	17.96	S	+5.2996	—1.0	0.7	2.8	167.7489	+0.3	167.7492	P.	J.
		N	+5.2976	+1.0						P.	F.
		Mean	+5.2986								
T. B. M. 12 and 12*a*	18.49	S	+0.6879	—0.4	0.3		163.1378			P.	F.
		N	+0.6871	+0.4						P.	F.
		Mean	+0.6875								
* B. M. Marr	19.81	N	—2.1847	—1.4	1.0		160.9517			P.	J. F.
		S	—2.1876	+1.5						P.	J. F.
		Mean	—2.1861								
T. B. M. 13	20.05	S	+1.6031	+0.3	0.2		164.7412			P.	F.
		N	+1.6037	—0.3						P.	F.
		Mean	+1.6034								
T. B. M. 14 and 14*a*	21.65	N	+4.9501	+1.5	1.0		169.6928			P.	J.
		S	+4.9530	—1.4						P.	J.
		Mean	+4.9516								
T. B. M. 15 and 15*a*	23.03	N	+1.1984	—0.4	0.3		170.8908			P.	J.
		S	+1.1976	+0.4						P.	J.
		Mean	+1.1980								
T. B. M. 16 and 16*a*	24.56	S	+4.8819	—1.7	1.1		175.7710			P.	J.
		N	+4.8786	+1.6						P.	J.
		Mean	+4.8802								
T. B. M. 17	25.44	S	+0.7768	0.0	0.0		176.5478			P.	F.
		N	+0.7769	—0.1						P.	F.
		Mean	+0.7768								
U. S. P. B. M. 4	26.56	S	—4.8804	+0.3	0.2	3.1	171.6677	+0.4	171.6681	P.	F.
		N	—4.8798	—0.3						P.	F.
		Mean	—4.8801								
U. S. P. B. M. 5	27.50	S	—1.8070	—0.8	0.5	3.2	169.8599	+0.4	169.8603	P.	F.
		N	—1.8085	+0.7						P.	F.
		Mean	—1.8078								
U. S. P. B. M. 6	28.94	S	+1.5098	+1.3	0.9	3.3	171.3710	+0.4	171.3714	P.	F.
		N	+1.5125	—1.4						P.	F.
		Mean	+1.5111								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T. B. M. 18 and 18*a*	30. 42	S........	+5. 7398	+1. 4	0. 9	......	177. 1122	......	....	P.	J.
		N	+5. 7426	—1. 4	......	......	....	......	....	P.	J.
		Mean..	+5. 7412								
T. B. M. 19 and 19*a*	31. 91	S........	—5. 9833	—1. 8	1. 2	......	171. 1271	......	....	P.	J.
		N	—5. 9870	+1. 9	......	......	....	......	....	P.	J.
		Mean..	—5. 9851								
T. B. M. 20........	33. 64	S........	—1. 2207	—0. 6	0. 4	......	169. 9058	......	....	P.	J.
		N	—1. 2219	+0. 6	......	......	....	......	....	P.	J.
		Mean..	—1. 2213								
T. B. M. 22........	35. 32	N	—1. 1248	+0. 5	0. 3	......	168. 7815	......	....	P.	F.
		S........	—1. 1239	—0. 4	......	......	....	......	....	P.	F.
		Mean..	—1. 1243								
T. B. M. 23........	36. 87	N	—2. 5940	—1. 4	0. 9	......	166. 1861	......	....	P.	F.
		S........	—2. 5968	+1. 4	......	......	....	......	....	P.	F.
		Mean..	—2. 5954								
T. B. M. 24........	38. 56	S........	—0. 0346	—0. 7	0. 5	......	166. 1508	......	....	P.	F.
		N	—0. 0360	+0. 7	......	......	....	......	....	P.	F.
		Mean..	—0. 0353								
U. S. P. B. M. 7....	38. 69	N	+2. 8397	+0. 1	0. 1	3. 8	168. 9906	+0. 4	168. 9910	P.	J.
		S........	+2. 8400	—0. 2	......	......	....	......	....	P.	F.
		Mean..	+2. 8398								
T. B. M. 25........	39. 50	N	—2. 7120	—0. 3	0. 2	......	166. 2783	......	....	P.	J.
		S........	—2. 7126	+0. 3	......	......	....	......	....	P.	F.
		Mean..	—2. 7123								
[1]U. S. P. B. M. 8 ..	39. 57	N	+4. 2845	—0. 4	0. 2	3. 8	170. 5624	+0. 4	170. 5628	P.	J.
		S........	+4. 2838	+0. 3	......	......	....	......	....	P.	F.
		Mean..	+4. 2841								
T. B. M. 26........	40. 29	N	—1. 4030	—0. 2	0. 2	......	164. 8751	......	....	P.	F.
		S........	—1. 4035	+0. 3	......	......	....	......	....	P.	F.
		Mean..	—1. 4032								
T.B.M.27 and 27*a*.	41. 90	N.......	+0. 6605	+1. 9	1. 3	......	165. 5375	......	....	P.	F.
		S	+0. 6644	—2. 0	......	......	....	......	....	P.	F.
		Mean ..	+0. 6624								
T. B. M. 28........	43. 33	N.......	+5. 3031	0. 0	0. 0	......	170. 8406	......	....	P.	F.
		S	+5. 3032	—0. 1	......	......	....	......	....	P.	F.
		Mean ..	+5. 3031								
T.B.M.29 and 29*a*.	44. 87	N.......	—5. 3617	+2. 2	0. 6	......	165. 4811	......	....	P.	J.
		N.......	—5. 3605	+1. 0	......	......	....	......	....	F.	J.
		S	—5. 3552	—4. 3	......	......	....	......	....	P.	J.
		S	—5. 3592	—0. 3	......	......	....	......	....	F.	J.
		S	—5. 3604	+0. 9	......	......	....	......	....	P.	J.
		S	—5. 3601	+0. 6	......	......	....	......	....	F.	J.
		Mean ..	—5. 3595								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T. B. M. 30........	45.52	N.......	+4.9114	+0.6	0.2	......	170.3931	......	....	P.	J.
		N.......	+4.9121	−0.1	......	......	....	......	....	F.	J.
		S	+4.9117	+0.3	......	......	....	......	....	P.	J.
		S	+4.9129	−0.9	......	......	....	......	....	F.	J.
		Mean ..	+4.9120								
*U. S. P. B. M. 9...	45.70	N.......	+2.0966	+0.6	0.3	4.1	172.4903	+0.5	172.4908	P.	J.
		S	+2.0982	−1.0	......	......	....	......	....	P.	F.
		S	+2.0968	+0.4	......	......	....	......	....	P.	F.
		Mean ..	+2.0972								
T. B. M. 31........	45.77	N.......	+1.1858	−0.3	0.1	......	171.5786	......	....	P.	J.
		N.......	+1.1855	0.0	......	......	....	......	....	F.	J.
		S	+1.1851	+0.4	......	......	....	......	....	P.	J.
		S	+1.1857	−0.2	......	......	....	......	....	F.	J.
		Mean ..	+1.1855								
T. B. M. 32........	46.79	N.......	−5.7835	+2.5	0.9	......	165.7976	......	....	P.	F.
		S	−5.7787	−2.3	......	......	....	......	....	P.	F.
		S	−5.7809	−0.1	......	......	....	......	....	P.	F.
		Mean ..	−5.7810								
T. B. M. 33 and 33*a*.	47.53	N.......	+0.9247	+0.8	0.5	......	166.7231	......	....	P.	F.
		S	+0.9263	−0.8	......	......	....	......	....	P.	F.
		Mean ..	+0.9255								
T. B. M. 34........	48.94	N.......	+4.9363	−0.1	0.1	......	171.6593	......	....	P.	F.
		S	+4.9361	+0.1	......	......	....	......	....	P.	F.
		Mean ..	+4.9362								
T. B. M. 35 and 35*a*.	50.58	N.......	−1.5295	+2.3	0.6	......	170.1321	......	....	P.	J.
		N.......	−1.5258	−1.4	......	......	....	......	....	F.	J.
		S	−1.5264	−0.8	......	......	....	......	....	P.	J.
		S	−1.5271	−0.1	......	......	....	......	....	F.	J.
		Mean ..	−1.5272								
T. B. M. 36........	52.19	N.......	+0.0061	−3.6	0.9	......	170.1346	......	....	P.	J.
		N.......	+0.0004	+2.1	......	......	....	......	....	F.	J.
		S	+0.0005	+2.0	......	......	....	......	....	P.	J.
		S	+0.0030	−0.5	......	......	....	......	....	F.	J.
		Mean ..	+0.0025								
U. S. P. B. M. 10...	53.71	N.......	+2.9911	−2.2	1.4	4.6	173.1235	+0.5	173.1240	P.	F.
		S	+2.9868	+2.1	......	......	....	......	....	P.	F.
		Mean ..	+2.9889								
T. B. M. 37........	54.92	N.......	+2.6984	+1.8	1.2	......	175.8237	......	....	P.	F.
		S	+2.7020	−1.8	......	......	....	......	....	P.	F.
		Mean ..	+2.7002								
T. B. M. 38 and 38*a*	55.70	N.......	−1.6462	+1.9	0.7	......	174.1794	......	....	P.	J.
		N.......	−1.6456	+1.3	......	......	....	......	....	F.	J.
		S	−1.6417	−2.6	......	......	....	......	....	P.	J.
		S	−1.6438	−0.5	......	......	....	......	....	F.	J.
		Mean ..	−1.6443								
T. B. M. 39........	56.46	S	−0.0696	−2.6	0.8	......	174.1072	......	....	P.	J.
		S	−0.0707	−1.5	......	......	....	......	....	F.	J.
		N.......	−0.0749	+2.7	......	......	....	......	....	P.	J.
		N.......	−0.0735	+1.3	......	......	....	......	....	F.	J.
		Mean ..	−0.0722								

Results of precise leveling—Continued.

KEOKÚK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T.B.M.40 and 40*a*.	57.74	N	+0.0444	+0.5	0.3		174.1521			P.	F.
		S	+0.0454	−0.5						P.	F.
		Mean	+0.0449								
T.B.M.41 and 41*a*.	59.28	N	−0.5881	−1.6	1.1		173.5624			P.	F.
		S	−0.5914	+1.7						P.	F.
		Mean	−0.5897								
*U. S. P. B. M. 11	59.85	N	−2.8540	+0.3	0.2	5.0	170.7087	+0.4	170.7091	P. F.	J.
		N	−2.8535	−0.2						P. F.	J. F.
		Mean	−2.8537								
T.B.M.42 and 42*a*.	60.83	S	−5.1594	−3.7	0.9		168.8993			P.	J.
		S	−5.1628	−0.8						F.	J.
		N	−5.1652	+2.1						P.	J.
		N	−5.1651	+2.0						F.	J.
		Mean	−5.1631								
T.B.M.43 and 43*a*.	62.13	S	−1.0536	+1.0	0.5		167.3467			P.	J.
		S	−1.0535	+0.9						F.	J.
		N	−1.0504	−2.2						P.	J.
		N	−1.0529	+0.3						F.	J.
		Mean	−1.0526								
T.B.M.44 and 44*a*.	63.80	S	+0.4902	+1.7	1.2		167.8386			P.	F.
		N	+0.4937	−1.8						P.	F.
		Mean	+0.4919								
T.B.M.45 and 45*a*.	65.52	S	+0.1928	−0.5	0.3		168.0309			P.	F.
		N	+0.1918	+0.5						P.	F.
		Mean	+0.1923								
*U. S. P. B. M. 12	66.37	S	+0.1333	+1.2	0.8	5.3	168.1654	+0.3	168.1657	P.	F.
		N	+0.1357	−1.2						P.	J. F.
		Mean	+0.1345								
T. B. M. 46	66.93	S	+2.3135	−0.6	0.4		170.8488			P.	F.
		N	+2.3124	+0.5						P.	F.
		Mean	+2.3129								
U. S. P. B. M. 13	68.06	S	+1.0521	+0.5	0.3	5.2	171.8964	+0.4	171.8968	P.	J.
		S	+1.0518	+0.8						F.	J.
		N	+1.0541	−1.5						P.	J.
		N	+1.0526	0.0						F.	J.
		Mean	+1.0526								
*100 ft. mark of water-gauge at Burlington Bridge, Iowa.	68.58		−3.8399	+5.4	3.6		167.5619			P. F.	J.
			−3.8291	−5.4						P.	J. F.
		Mean	−3.8345								
T. B. M. 47	69.74	N	+0.0382	−1.2	0.6		171.4334			(†)	J.
		S	+0.0386	−1.6						(†)	J.
		N	+0.0365	+0.5						(†)	F.
		S	+0.0348	+2.2						(†)	F.
		Mean	+0.0370								

† Bridge crossing.

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
*T. B. M. 49, Mackenzie.	69.77	N	+0.0071			5.3	171.4405	+0.4	171.4409	F.	J.
U. S. P. B. M. 14	69.78	N	+0.0011	+0.3	0.2	5.3	171.4348	+0.4	171.4352		J.
		S	+0.0017	—0.3							J.
		Mean	+0.0014								
T. B. M. 47½	70.86	N	—2.9537	—1.7	1.0		168.4794			F.	J.
		S	—2.9600	+4.6						F.	J.
		S	—2.9542	—1.2						P.	J.
		S	—2.9538	—1.6						F.	J.
		Mean	—2.9554								
T. B. M. 48	71.39	N	—0.6837	+0.2	0.1		167.7959			F.	J.
		S	—0.6833	—0.2						F.	J.
		Mean	—0.6835								
T.B.M.49 and 49a.	72.75	N	—0.1559	—0.6	0.4		167.6394			P.	F.
		S	—0.1571	+0.6						P.	F.
		Mean	—0.1565								
U. S. P. B. M. 15	73.17	S	+0.0361	+0.6	0.4	5.4	167.6761	+0.3	167.6764	P.	F.
		N	+0.0373	—0.6						P.	F.
		Mean	+0.0367								
T.B.M.50 and 50a.	74.51	S	+0.2400	+1.0	0.7		167.9171			P.	F.
		N	+0.2421	—1.1						P.	F.
		Mean	+0.2410								
T. B. M. 51	75.45	N	—0.0500	—0.5	0.4		167.8666			F.	J.
		S	—0.0511	+0.6						F.	J.
		Mean	—0.0505								
T.B.M.52 and 52a.	76.23	N	+0.0799	+0.9	0.6		167.9474			F.	J.
		S	+0.0818	—1.0						F.	J.
		Mean	+0.0808								
T. B. M. 53	77.13	N	+0.2068	—1.1	0.7		168.1531			F.	J.
		S	+0.2046	+1.1						F.	J.
		Mean	+0.2057								
T. B. M. 54	78.58	N	+0.0108	—2.6	1.8		168.1613			F.	J.
		S	+0.0055	+2.7						F.	J.
		Mean	+0.0082								
*U. S. P. B. M. 16	78.60	N	+0.0018	+0.1	0.1	5.8	168.1632	+0.3	168.1635		F.
		N	+0.0021	—0.2							F.
		Mean	+0.0019								
T. B. M. 55	79.80	N	+0.4836	+1.6	1.1		168.6465			P.	F.
		S	+0.4869	—1.7						P.	F.
		Mean	+0.4852								
T. B. M. 56 and 56a	81.17	N	+3.3703	+1.4	0.9		172.0182			P.	F.
		S	+3.3730	—1.3						P.	F.
		Mean	+3.3717								
T. B. M. 56 A	83.07	S	—0.3153	+0.3	0.2		171.7032			P.	F.
		N	—0.3147	—0.3						P.	F.
		Mean	—0.3150								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T. B. M. 56 B. and 56 B¹.	83. 88	S	—2. 8566	+0. 8	0. 5		168. 8474			P.	J.
		N	—2. 8551	—0. 7						P.	J.
		Mean..	—2. 8558								
T. B. M. 57	84. 34	S	+1. 4624	+0. 8	0. 5		170. 3106			P.	J.
		N	+1. 4639	—0. 7						P.	J.
		Mean..	+1. 4632								
T. B. M. 58 and 58*a*	85. 30	S	—1. 3600	+3. 4	0. 7		168. 9540			P.	J.
		N	—1. 3501	—6. 5						P.	J.
		N	—1. 3557	—0. 9						P.	J.
		N	—1. 3557	—0. 9						F.	J.
		S	—1. 3575	+0. 9						P.	J.
		S	—1. 3562	—0. 4						F.	J.
		N	—1. 3584	+1. 8						P.	J.
		N	—1. 3589	+2. 3						F.	J.
		Mean..	—1. 3566								
T. B. M. 59 and 59*a*	86. 63	S	—0. 7065	—1. 1	0. 8		168. 2464			P.	F.
		N	—0. 7088	+1. 2						P.	F.
		Mean..	—0. 7076								
T. B. M. 60	87. 84	N	+0. 5054	+0. 6	0. 4		168. 7524			P.	F.
		S	+0. 5067	—0. 7						P.	F.
		Mean..	+0. 5060								
T. B. M. 61 and 61*a*	89. 06	N	—0. 6258	+1. 0	0. 7		168. 1276			P.	F.
		S	—0. 6237	—1. 1						P.	F.
		Mean..	—0. 6248								
T. B. M. 62	90. 64	N	+0. 7707	+1. 5	1. 0		168. 8998			P.	F.
		S	+0. 7737	—1. 5						P.	F.
		Mean..	+0. 7722								
*U. S. P. B. M. 17	90. 66	S	+0. 6258	+0. 2	0. 1	6. 3	169. 5258	+0. 4	169. 5262		F.
		N	+0. 6262	—0. 2							J.
		Mean..	+0. 6260								
*U. S. P. B. M. 18	90. 84	N	+4. 2359	+0. 5	0. 3	6. 8	173. 1362	+0. 5	173. 1367		J.
		S	+4. 2369	—0. 5							F.
		Mean..	+4. 2364								
*P. B. M. 48, Mackenzie.	90. 66	N	—0. 0034	—0. 2	0. 1	6. 3	168. 8962	+0. 4	168. 8966		F.
		N	—0. 0038	+0. 2							J.
		Mean..	—0. 0036								
*H. W. mark, 1851, Oquawka, Ill.	90. 69	N	+0. 0617	—2. 5	1. 6		168. 9590				J.
		N	+0. 0568	+2. 4							F.
		Mean..	+0. 0592								
T. B. M. 63 and 63*a*	91. 40	N	+5. 1117	—1. 0	0. 7		174. 0105			P.	F.
		S	+5. 1097	+1. 0						P.	F.
		Mean..	+5. 1107								
T. B. M. 64	92. 14	N	+3. 8966	0. 0	0. 0		177. 9071			F.	J.
		S	+3. 8965	+0. 1						F.	J.
		Mean..	+3. 8966								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T. B. M. 65 and 65*a*	93.15	N	−0.2095	+0.9	0.6	......	177.6985	......	....	F.	J.
		S	−0.2077	−0.9	......	......	....	......	....	F.	J.
		Mean..	−0.2086								
T. B. M. 66 and 66*a*	94.22	N	+1.8989	+0.4	0.3	......	179.5978	......	....	F.	J.
		S	+1.8997	−0.4	......	......	....	......	....	F.	J.
		Mean..	+1.8993								
T. B. M. 67 and 67*a*	05.96	N	+0.4591	−5.2	1.5	......	180.0517	......	....	P.	F.
		S	+0.4491	+4.8	......	......	....	......	....	P.	F.
		N	+0.4554	−1.5	......	......	....	......	....	F.	F.
		S	+0.4521	+1.8	......	......	....	......	....	F.	F.
		Mean..	+0.4539								
T. B. M. 68 and 68*a*	96.60	N	−1.4635	−1.1	0.7	......	178.5871	......	....	F.	F.
		S	−1.4657	+1.1	......	......	....	......	....	F.	F.
		Mean..	−1.4646								
T. B. M. 69	97.81	N	−1.8309	−0.9	0.6	......	176.7553	......	....	F.	J.
		S	−1.8328	+1.0	......	......	....	......	....	F.	J.
		Mean..	−1.8318								
T. B. M. 70 and 70*a*	99.20	N	+2.0445	+0.4	0.3	......	178.8002	......	....	F.	J.
		S	+2.0453	−0.4	......	......	....	......	....	F.	J.
		Mean..	+2.0449								
T. B. M. 71 and 71*a*	100.28	S	−0.4615	+0.5	0.3	......	178.3392	......	....	F.	J.
		N	−0.4606	−0 4	......	......	....	......	....	F.	J.
		Mean..	−0.4610								
T. B. M. 72 and 72*a*	101.57	N	−0.6854	+0.2	0.1	......	177.6540	......	....	F.	F.
		S	−0.6851	−0.1	......	......	....	......	....	F.	F.
		Mean..	−0.6852								
T. B. M. 73 and 73*a*	104 09	N	+1.9325	−1.9	1.2	......	179.5846	......	....	F.	F.
		S	+1.9288	+1.8	......	......	....	......	....	F.	F.
		Mean..	+1.9306								
T. B. M. 74	105.18	N	−0.5974	−1.5	1.3	......	178.9857	......	....	F.	J.
		S	−0.6028	+3.9	.....	......	....	......	....	F.	J.
		N	−0.5964	−2.5	......	......	....	......	....	F.	F.
		Mean..	−0.5989								
T. B. M. 75	106.45	N	+2.7744	+0.4	0.3	......	181.7605	......	....	F.	J.
		S	+2.7752	−0.4	......	......	....	......	....	F.	J.
		Mean..	+2.7748								
T. B. M. 76 and 76*a*	107.27	N	−0.3881	−0.3	0.2	......	181.3721	......	....	F.	J.
		S	−0.3887	+0.3	......	......	....	......	....	F.	J.
		Mean..	−0.3884								
T. B. M. 77 and 77*a*	108.58	N	−2.2738	−0.4	0.3	......	179.0979	......	....	F.	J.
		S	−2.2747	+0.5	.....	......	....	......	....	F.	J.
		Mean..	−2.2742								
T. B. M. 78 and 78*a*	109 91	N	−8.0692	−0.6	0.4	......	171.0281	......	....	F.	F.
		S	−8.0705	+0.7	......	......	....	......	....	F.	F.
		Mean..	−8.0698								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T. B. M. 79 and 79*a*	111. 00	N	−1. 7230	−0. 5	0. 3		169. 3046			F.	F.
		S	−1. 7240	+0. 5						F.	F.
		Mean	−1. 7235								
*U. S. P. B. M. 19	111. 47	N	+1. 3198	+0. 4	0. 2	6. 9	170. 6248	+0. 4	170. 6252	F.	J.
		S	+1. 3205	−0. 3						F.	J.
		Mean	+1. 3202								
*U. S. P. B. M. 20	111. 30	N	+4. 3437			6. 9	173. 6483	+0. 5	173. 6488	F.	J.
*P. B. M. 47, Mackenzie.	111. 54	N	+1. 3181			6. 9	170. 6227	+0. 4	170. 6231	F.	J.
*H. W. mark, 1851, Keithsburg, Ill.	111. 54	N	+1. 0881				170. 3927			F.	J.
*H. W. mark, 1881, Keithsburg, Ill.	111. 63	N	+0. 6733				169. 9779			F.	J.
T. B. M. 80	111. 40	N	+1. 0671	−0. 3	0. 2		170. 3714			F.	F.
		S	+1. 0664	+0. 4						F.	F.
		Mean	+1. 0668								
T. B. M. 81 and 81*a*	111. 87	N	+2. 6500	−0. 6	0. 4		173. 0208			F.	F.
		S	+2. 6487	+0. 7						F.	F.
		Mean	+2. 6494								
T. B. M. 82 and 82*a*	113. 40	N	+6. 2676	−1. 6	1. 1		179. 2868			F.	F.
		S	+6. 2643	+1. 7						F.	F.
		Mean	+6. 2660								
T. B. M. 83 and 83*a*	114. 63	N	+0. 8725	+0. 2	0. 1		180. 1595			F.	F.
		S	+0. 8729	−0. 2						F.	F.
		Mean	+0. 8727								
T. B. M. 84	116. 10	N	+0. 7559	+4. 0	1. 1		180. 9194			F.	J.
		S	+0. 7639	−4. 0						F.	J.
		N	+0. 7596	+0. 3						F.	J.
		S	+0. 7603	−0. 4						F.	J.
		Mean	+0. 7599								
T. B. M. 85 and 85*a*	117. 45	N	−0. 0186	+1. 3	0. 9		180. 9021			F.	J.
		S	−0. 0160	−1. 3						F.	J.
		Mean	−0. 0173								
T. B. M. 86	118. 75	N	-0. 6858	−0. 6	0. 4		180. 2157			F.	J.
		S	−0. 6870	+0. 6						F.	J.
		Mean	−0. 6864								
T. B. M. 87	119. 81	N	−1. 1346	−1. 8	1. 2		179. 0793			F.	J.
		S	−1. 1383	+1. 9						F.	J.
		Mean	−1. 1364								
T. B. M. 88 and 88*a*	120. 82	N	−3. 8750	−1. 2	0. 8		175. 2031			F.	J.
		S	−3. 8775	+1. 3						F.	J.
		Mean	−3. 8762								
*U. S. P. B. M. 21	120. 84	N	+0. 0590	−0. 4	0. 2	7. 3	175. 2617	+0. 5	175. 2622		F.
		S	+0. 0583	+0. 3							F.
		Mean	+0. 0586								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T. B. M. 89 and 89*a*	124.24	N	+2.0934	—0.3	0.2		177.2962			F.	F.
		S	+2.0928	+0.3						F.	F.
		Mean..	+2.0931								
U. S. P. B. M. 22 ..	124.56	N	—5.0325	—0.3	0.2	7.3	172.2634	+0.5	172.2639	F.	F.
		S	—5.0331	+0.3						F.	F.
		Mean..	—5.0328								
*P. B. M. 46, Mackenzie.	124.77	N	—1.6855	0.0	0.0		170.5779	+0.4	170.5783		F.
		S	—1.6855	0.0							F.
		Mean..	—1.6855								
*U. S. P. B. M. 23..	124.82	N	+7.7472	+0.4	0.8	7.8	180.0110	+0.7	180.0117		F.
		S	+7.7481	—0.5							F.
		Mean..	+7.7476								
*H. W. Mark, 1881, New Boston, Ill.	124.62	N	—1.4046				170.8588				F.
T. B. M. 90	124.77	N	—4.8082	—0.9	0.6		167.4543			F.	J.
		S	—4.8100	+0.9						F.	J.
		Mean..	—4.8091								
T. B. M. 91	125.14	N	—0.0031	—0.8	0.6		167.4345			(*)	J.
		S	—0.0349								J.
		N	—0.0083	+0.9							F.
		S	—0.0331								F.
		Mean..	—0.0198								
T. B. M. 92 and 92*a*	125.23	N	+0.5673	—0.1	0.0		168.0017			P.	F.
		S	+0.5672	0.0						P.	F.
		Mean..	+0.5672								
T. B. M. 93	126.31	N	+1.6575	—1.1	0.8		169.6581			P.	F.
		S	+1.6562	+0.2						P.	F.
		N	+1.6532	+3.2						F.	F.
		S	+1.6588	—2.4						F.	F.
		Mean..	+1.6564								
T B. M. 94	127.18	N	—1.5050	—0.5	0.2		168.1526			P.	F.
		S	—1.5053	—0.2						P.	F.
		N	—1.5061	+0.6						F.	F.
		S	—1.5056	+0.1						F.	F.
		Mean..	—1.5055								
T. B. M. 95	128.40	N	+1.8817	+1.8	0.8		170.0356			P.	J.
		N	+1.8803	+2.7						F.	J.
		S	+1.8851	—2.1						P.	J.
		S	+1.8851	—2.1						F.	J.
		Mean..	+1.8830								
T. B. M. 96	129.39	N	—1.0376	+0.6	0.4		168.9986			P.	J.
		S	—1.0364	—0.6						P.	J.
		Mean..	—1.0370								
T. B. M. 97	130.31	N	+0.6427	—0.9	0.6		169.6404			P.	J.
		S	+0.6410	+0.8						P.	J.
		Mean..	+0.6418								

* Crossing New Boston Bay.

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T. B. M. 98 and 98*a*	132.22	N	—0.0956	—1.4	0.9		169.5434			P.	F.
		S	—0.0984	+1.4						P.	F.
		Mean	—0.0970								
T. B. M. 99	133.37	N	+1.1632	—0.4	0.3		170.7062			P.	F.
		S	+1.1624	+0.4						P.	F.
		Mean	+1.1628								
T. B. M. 100	134.64	N	—0.5866	—0.6	0.4		170.1190			P.	J.
		S	—0.5877	+0.5						P.	J.
		Mean	—0.5872								
T. B. M. 101	135.46	N	—0.6478	+0.9	0.6		169.4721			P.	J.
		S	—0.6460	—0.9						P.	J.
		Mean	—0.6469								
T. B. M. 102	136.03	N	—0.2514	+2.0	0.6		169.2227			P.	F.
		S	—0.2470	—2.4						P.	F.
		N	—0.2493	—0.1						P.	F.
		S	—0.2501	+0.7						P.	F.
		Mean	—0.2494								
T. B. M. 103	136.18	N	—0.3069	—0.5	0.4		168.9158			P.	F.
		S	—0.3080	+0.6						P.	F.
		Mean	—0.3074								
T. B. M. 104	136.42	N	+0.0031	—0.2	0.1		168.9182			P.	J.
		S	+0.0027	+0.2						P.	J.
		Mean	+0.0029								
T. B. M. 105	136.96	N	—0.0307	+0.4	0.8		168.9178			(*)	J.
		S	+0.0290								J.
		N	—0.0212	—0.5							F.
		S	+0.0214								F.
		Mean	—0.0004								
T. B. M. 106	138.60	N	+2.1158	+4.0	1.1		171.0371			P.	J.
		S	+2.1231	—3.8						P.	J.
		N	+2.1188	+0.5						P.	J.
		S	+2.1199	—0.6						P.	J.
		Mean	+2.1193								
*U. S. P. B. M. 24=Mackenzie B. M. 45.	138.62	S	+1.2697	+0.1	0.0	7.7	172.3069	+0.5	172.3074		J.
		S	+1.2698	0.0							F.
		Mean	+1.2698								
T. B. M. 107	139.61	N	—1.1292	+4.2	1.0		169.9121			P.	J.
		S	—1.1232	—1.8						P.	J.
		N	—1.1250	0.0						P.	F.
		S	—1.1228	—2.2						P.	F.
		Mean	—1.1250								
T. B. M. 108 and 108a.	141.24	N	—0.6700	+0.4	0.2		169.2425			P.	F.
		S	—0.6693	—0.3						P.	F.
		Mean	—0.6696								
T. B. M. 109	142.36	N	+1.0217	—0.1	0.0		170.2641			P.	F.
		S	+1.0216	0.0						P.	F.
		Mean	+1.0216								

* River crossing.

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
*H. W. Mark, 1881, Port Louisa, Iowa.	141.86	S	+1.0536	......	......	......	171.3177	......	....	P.	F.
T. B. M. 110	144.08	N	+0.3250	−2.9	1.1	......	170.5862	......	....	P.	J.
		S	+0.3194	+2.7	......	......	....	......	....	P.	J.
		N	+0.3218	+0.3	......	......	....	......	....	P.	J.
		Mean..	+0.3221								
T. B. M. 111	145.71	N	+0.3540	−0.5	0.3	......	170.9397	......	....	P.	J.
		S	+0.3530	+0.5	......	......	....	......	....	P.	J.
		Mean..	+0.3535								
T. B. M. 112	146.30	N	−0.3593	−1.8	1.2	......	170.5786	......	....	P.	F.
		S	−0.3629	+1.8	......	......	....	......	....	P.	F.
		Mean..	−0.3611								
T. B. M. 113	146.98	N	+0.4048	+0.1	0.1	......	170.9835	......	....	P.	F.
		S	+0.4050	−0.1	......	......	....	......	....	P.	F.
		Mean..	+0.4049								
T. B. M. 114 and 114*a*.	147.81	N	+1.3335	−1.5	1.0	......	172.3155	......	....	P.	F.
		S	+1.3306	+1.4	......	......	....	......	....	P.	F.
		Mean..	+1.3320								
T. B. M. 115	148.80	N	+0.2448	−3.2	1.1	......	172.5571	......	....	P.	F.
		S	+0.2398	+1.8	......	......	....	......	....	P.	F.
		N	+0.2401	+1.5	......	......	....	......	....	P.	F.
		Mean..	+0.2416								
T. B. M. 116	149.32	N	−1.0220	−0.6	0.4	......	171.5345	......	....	P.	F.
		S	−1.0231	+0.5	......	......	....	......	....	P.	F.
		Mean..	−1.0226								
T. B. M. 117	150.72	N	+0.0247	−1.1	0.7	......	171.5581	......	....	P.	J.
		S	+0.0225	+1.1	......	......	....	......	....	P.	J.
		Mean..	+0.0236								
*U. S. P. B. M. 25 .	150.85	S	+0.4415	+0.9	0.6	3.1	172.0005	+0.5	172.0010	P.	J.
		N	+0.4434	−1.0	......	......	....	......	....	P.	F.
		Mean..	+0.4424								
*H. W. Mark, June, 1880.	150.85	N	+0.3606	......	......	......	171.9187	......	....	....	F.
*H. W. Mark, 1851	150.90	N	+0.0010	......	......	......	172.0015	......	....	....	F.
*H. W. Mark, Oct., 1881.	150.90	N	−0.0157.	......	......	......	171.9848	......	....	....	F.
T. B. M. 118	151.65	N	+1.5861	+1.9	1.3	......	173.1461	......	....	P.	J.
		S	+1.5899	−1.9	......	......	....	......	....	P.	J.
		Mean..	+1.5880								
*U. S. P. B. M. 26 .	151.68	N	+0.1078	......	......	3.2	173.2539	+0.5	173.2544	....	J.
T. B. M. 119	152.96	N	−1.8469	−0.5	0.3	......	171.2987	......	....	P.	J.
		S	−1.8478	+0.4	......	......	....	......	....	P.	J.
		Mean..	−1.8474								
T. B. M. 120 and 120*a*.	154.62	N	+0.9804	−0.6	0.4	......	172.2785	......	....	P.	F.
		S	+0.9791	+0.7	......	......	....	......	....	P.	F.
		Mean..	+0.9798								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T. B. M. 121	155.27	N	−2.5495	+1.0	0.7	......	169.7300	......	....	P.	F.
		S	−2.5475	−1.0	......	......	....	......	....	P.	F.
		Mean	−2.5485								
T. B. M. 122	156.49	N	+0.8871	+1.7	1.1	......	170.6188	......	....	P.	F.
		S	+0.8904	−1.6	......	......	....	......	....	P.	F.
		Mean	+0.8888								
T. B. M. 123	157.79	N	+2.0076	0.0	0.0	......	172.6264	......	....	P.	F.
		S	+2.0077	−0.1	......	......	....	......	....	P.	F.
		Mean	+2.0076								
T. B. M. 124	158.36	N	+0.1844	+0.2	0.1	......	172.8110	......	....	P.	J.
		S	+0.1848	−0.2	......	......	....	......	....	P.	J.
		Mean	+0.1846								
T. B. M. 125	159.31	N	+0.0818	+1.1	0.7	......	172,8939	......	....	P.	J.
		S	+0.0840	−1.1	......	......	....	......	....	P.	J.
		Mean	+0.0829								
*H. W. M., Apr. 21, 1870, 2¼ miles below Muscatine, Iowa.	159.36	N	−0.3710	......	......	......	172.5229	......	....	....	J.
*H. W. M., June 28, 1880.	159.36	N	−0.1720	......	......	......	172.7219	......	....	....	J.
*H. W. M., Oct., 1881.	159.36	N	−0.1350	......	......	......	172.7589	......	....	....	J.
T. B. M. 126	160.23	N	−1.0263	+1.1	0.7	......	171.8687	......	....	P.	J.
		S	−1.0241	−1.1	......	......	....	......	....	P.	J.
		Mean	−1.0252								
T. B. M. 127 and 127a.	160.36	N	−0.1105	−0.5	0.4	......	171.7577	......	....	P.	J.
		S	−0.1116	+0.6	......	......	....	......	....	P.	J.
		Mean	−0.1110								
*U. S. P. B. M. 27	161.08	N	+2.0790	−0.1	0.1	3.4	173,8366	+0.5	173.8371	P.	J.
		S	+2.0788	+0.1	......	......	....	......	....	P.	J.
		Mean	+2.0789								
T. B. M. 128 and 128a.	163.04	N	+1.3444	−1.2	0.8	......	173.1009	......	....	P.	J.
		S	+1.3419	+1.3	......	......	....	......	....	P.	J.
		Mean	+1.3432								
*H. W. M., June, 1880, Muscatine, Iowa.	163.10	N	−0.0277	......	......	......	173.0732	......	....	....	J.
*H. W. M., Oct., 1881.	163.10	N	−0.0027	......	......	......	173.0982	......	....	....	J.
T. B. M. 129	164.06	N	+0.0176	−1.6	1.1	......	173.1169	......	....	P.	F.
		S	+0.0144	+1.6	......	......	....	......	....	P.	F.
		Mean	+0.0160								
*U. S. P. B. M. 28	164.06	N	+1.1794	0.0	0.0	3.5	174.2963	+0.5	174.2968	....	F.
		S	+1.1794	0.0	......	......	....	......	....	....	F.
		Mean	+1.1794								
*P. B. M. 44, Mackenzie.	164.12	N	+0.2029	+0.1	0.1	3.5	173.3199	+0.5	173.3204	....	F.
		S	+0.2031	−0.1	......	......	....	......	....	....	F.
		Mean	+0.2030								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
*16 ft. mark in well of water works, Muscatine, Iowa.	164.15	N	—0.6287	—0.1	0.1	......	172.6911	......	....	....	F.
		S	—0.6290	+0.2	......	......	....	......	....	....	F.
		Mean..	—0.6288								
*H. W. M., Oct., 1881, Muscatine, Iowa.	164.14	N	—0.0129	+0.3	0.3	......	173.1043	......	....	....	F.
		S	—0.0122	—0.4	......	......	....	......	....	....	F.
		Mean..	—0.0126								
U. S. P. B. M. 29...	164.85	N	+1.3178	—0.3	0.2	8.5	174.4344	+0.5	174, 4349	P.	F.
		S	+1.3172	+0.3	......	......	....	......	....	P.	F.
		Mean..	+1.3175								
T. B. M. 130 and 130*a*.	165.44	N	—0.8964	+0.2	0.2	......	173.5302	......	....	P.	F.
		S	—0.8959	—0.3	......	......	....	......	....	P.	F.
		Mean..	—0.8962								
T. B. M. 131 and 131*a*.	166.99	N	+0.0599	+2.5	1.7	......	173.5986	......	....	P.	F.
		S	+0.0650	—2.6	......	......	....	......	....	P.	F.
		Mean..	+0.0624								
T. B. M. 132 and 132*a*.	168.84	N	+0.2340	—0.6	0.4	......	173.8320	......	....	P.	J.
		S	+0.2328	+0.6	......	......	....	......	....	P.	J.
		Mean..	+0.2334								
*U. S. P. B. M. 30.	169.47	N	+0.9610	......	......	8.7	174.7930	+0.5	174.7935	P.	J.
T. B. M. 133 and 133*a*.	170.10	N	+1.5424	—1.8	1.2	......	175.3726	......	....	P.	J.
		S	+1.5389	+1.7	......	......	....	......	....	P.	J.
		Mean..	+1.5406								
T. B. M. 134 and 134*a*.	171 58	N	+0.3503	+1.5	1.0	......	175.7244	......	....	P.	F.
		S	+0.3534	—1.6	......	......	....	......	....	P.	F.
		Mean..	+0.3518								
U. S. P. B. M. 31..	172.65	N	—1.1705	+0.3	0.2	8.8	174.5542	+0.5	174 5547	P.	F.
		S	—1.1699	—0.3	......	......	....	......	....	P.	F.
		Mean..	+1.1702								
T. B. M. 135.......	173.66	N	+1.3195	—0.8	0.5	......	175.8729	......	....	P.	F.
		S	+1.3179	+0.8	......	......	....	......	....	P.	F.
		Mean..	+1.3187								
*U. S. P. B. M. 32.	173.68	N	+1.3146	......	......	8.8	177.1875	+0.6	177.1881	....	J.
T. B. M. 136.......	174.15	N	+0.3607	—1.3	0.8	......	176.2323	......	....	P.	F.
		S	+0.3582	+1.2	......	......	....	......	....	P.	F.
		Mean..	+0.3594								
T. B. M. 137 and 137*a*.	175.50	N	+0.4745	—0.7	0.4	......	177.7061	......	....	P.	J.
		S	+1.4732	+0.6	......	......	....	......	....	P.	J.
		Mean..	+1.4738								
T. B. M. 138 and 138*a*.	176.72	N	—0.5076	+0.3	0.2	......	177.1988	......	....	P.	J.
		S	—0.5070	—0.3	......	......	....	......	....	P.	J.
		Mean..	—0.5073								
*U. S. P. B. M. 33.	176.96	N	—1.8109	+0.7	0.4	8.9	175.3886	+0.5	175.3891	P.	F.
		S	—1.8096	—0.6	......	......	....	......	....	P.	F.
		Mean..	—1.8102								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
*P. B. M. 43, Mackenzie.	177.24	N	—1.0170	......	......	8.9	176.1818	+0.6	176.1824	F.	J.
'Mackenzie, B. M., on Elm Tree, Fairport, Iowa.	177.36	N	—3.8621	+1.3	0.9	......	173.8380	+0.5	173.8385	F.	J.
		S	—3.8594	—1.4	......	......	....	......	....	F.	J.
		Mean ..	—3.8608								
T. B. M. 139 and 139a.	178.21	N	—0.8628	+0.3	0.2	......	176.8363	......	....	F.	J.
		S	—0.8622	—0.3	......	......	....	......	....	F.	J.
		Mean ..	—0.8625								
T. B. M. 140 and 140a.	179.59	N	+0.6706	—0.8	0.5	......	177.0061	......	....	F.	F.
		S	+0.6690	+0.8	......	......	....	......	....	F.	F.
		Mean ..	+0.6698								
T. B. M. 141 and 141a.	180.65	N	—1.3952	+1.2	0.8	......	175.6121	......	....	F.	F.
		S	—1.3928	—1.2	......	......	....	......	....	F.	F.
		Mean ..	—1.3940								
U. S. P. B. M. 34...	181.31	N	—0.5133	+0.5	0.3	8.9	175.0993	+0.5	175.0998	F.	J.
		S	—0.5123	—0.5	......	......	....	......	....	F.	J.
		Mean ..	—0.5128								
T. B. M. 142 and 142a.	181.98	N	+1.2352	—0.2	0.2	......	176.3343	......	....	F.	J.
		S	+1.2347	+0.3	......	......	....	......	....	F.	J.
		Mean ..	+1.2350								
T. B. M. 143 and 143a.	183.18	N	+0.2463	+3.8	0.9	......	176.5844	......	....	F.	J.
		S	+0.2527	—2.6	......	......	....	......	....	F.	J.
		N	+0.2512	—1.1	......	......	....	......	....	F.	J.
		S	+0.2501	0.0	......	......	....	......	....	F.	J.
		Mean ..	+0.2501								
T. B. M. 144 and 144a.	184.32	N	+1.8869	+4.0	0.7	......	178.4753	......	....	F.	F.
		S	+1.8922	—1.3	......	......	....	......	....	F.	F.
		N	+1.8918	—0.9	......	......	....	......	....	F.	F.
		S	+1.8927	—1.8	......	......	....	......	....	F.	F.
		N	+1.8909	0.0	......	......	....	......	....	F.	F.
		Mean ..	+1.8909								
T. B. M. 145.......	185.01	N	—0.2702	0.0	0.0	......	178.2051	......	....	F.	F.
		S	—0.2701	—0.1	......	......	....	......	....	F.	F.
		Mean ..	—0.2702								
*U. S. P. B. M. 35..	185.18	N	+0.0050	+0.4	0.2	9.0	178.2105	+0.6	178.2111	....	F.
		S	+0.0057	—0.3	......	......	....	......	....	....	F.
		Mean ..	+0.0054								
T. B. M. 146.......	186.07	N	—0.6355	—1.7	1.2	......	177.5679	......	....	F.	F.
		S	—0.6390	+1.8	......	......	....	......	....	F.	F.
		Mean ..	—0.6372								
U. S. P. B. M. 35A..	186.96	N	—1.6454	+0.2	0.1	9.1	175.9227	+0.6	175.9233	F.	J.
		S	—1.6451	—0.1	......	......	....	......	....	F.	J.
		Mean ..	—1.6452								
T. B. M. 147 and 147a.	187.43	N	+0.2814	+0.7	0.5	......	176.2948	......	....	F.	J.
		S	+0.2828	—0.7	......	......	....	......	....	F.	J.
		Mean ..	+0.2821								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T. B. M. 148 and 148*a*.	188.12	N.......	+2.2801	-1.5	1.0	......	178.4864	......	....	F.	J.
		S.......	+2.2830	+1.4	......	......	....	......	....	F.	J.
		Mean..	+2.2816								
T. B. M. 149 and 149*a*.	188.86	N.......	+0.2240	-0.2	0.1	......	178.7102	......	....	F.	F.
		S.......	+0.2236	+0.2	......	......	....	......	....	F.	F
		Mean..	+0.2238								
T. B. M. 150 and 150*a*.	190.18	N.......	+1.1952	0.0	0.0	......	179.9054	......	....	F.	F.
		S.......	+1.1951	+0.1	......	......	....	......	....	F.	F.
		Mean..	+1.1952								
T. B. M. 151 and 151*a*.	190.69	N.......	-0.6553	+0.3	0.2	......	179.2504	......	....	F.	J.
		S.......	-0.6546	-0.4	......	......	....	......	....	F.	J.
		Mean..	-0.6550								
T. B. M. 152 and 152*a*.	192.10	N.......	-3.4540	-0.6	0.4	......	175.7958	......	....	F.	J.
		S.......	-3.4553	+0.7	......	......	....	......	....	F.	J.
		Mean..	-3.4546								
T. B. M. 153.......	192.43	N.......	-0.0522	-0.1	0.1	......	175.7435	......	....	F.	F.
		S.......	-0.0524	+0.1	......	......	....	......	....	F.	F.
		Mean..	-0.0523								
T. B. M. 154.......	192.93	N.......	+0.1140	+2.5	0.6	......	175.8600	......	....	F.	F.
		S.......	+0.1182	-1.7	......	......	....	......	....	F.	F.
		N.......	+0.1162	+0.8	......	......	....	......	....	F.	F.
		S.......	+0.1177	-1.2	......	......	....	......	....	F.	F.
		Mean..	+0.1165								
*U. S. P. B. M. 86..	193.12	N.......	+2.5400	0.0	0.0	9.2	178.4000	+0.6	178.4006	F.	J.
		S.......	+2.5399	+0.1	......	......	....	......	....	F.	J.
		Mean..	+2.5400								
T. B. M. 155 and 155*a*.	193.49	N.......	+0.0378	+0.2	0.1	......	175.8980	......	....	F.	F.
		S.......	+0.0381	-0.1	......	......	....	......	....	F.	F.
		Mean..	+0.0380								
T. B. M. 156.......	194.45	N.......	+0.5318	+3.4	1.0	......	176.4332	......	....	F.	J.
		S.......	+0.5379	-2.7	......	......	....	......	....	F.	J.
		N.......	+0.5372	-2.0	......	......	....	......	....	F.	J.
		S.......	+0.5341	+1.1	......	......	....	......	....	F.	J.
		Mean..	+0.5352								
*U. S. P. B. M. 87..	194.52	N.......	+3.0326	+0.4	0.2	9.2	179.4662	+0.7	179.4669	....	F.
		S.......	+3.0333	-0.3	......	......	....	......	....	....	F.
		Mean..	+3.0330								
T. B. M. 157 and 157*a*.	195.10	N.......	+0.6062	+1.0	0.7	......	177.0404	......	....	F.	J.
		S.......	+0.6083	-1.1	......	......	....	......	....	F.	J.
		Mean..	+0.6072								
T. B. M. 158.......	196.06	N.......	+0.9624	+1.3	0.9	......	178.0041	......	....	F.	F.
		S.......	+0.9650	-1.3	......	......	....	......	....	F.	F.
		Mean..	+0.9637								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T. B. M. 159 and 159a.	196.69	N.......	+0.2235	+1.7	0.5	......	178.2293	......	....	F.	F.
		S.......	+0.2268	—1.6	......	......	....	......	....	F.	F.
		N.......	+0.2259	—0.7	......	......	....	......	....	F.	F.
		S.......	+0.2248	+0.4	......	......	....	......	....	F.	F.
		Mean..	+0.2252								
T. B. M. 160 and 160a.	196.93	N.......	+1.0638	+1.3	0.4	......	179.2944	......	....	F.	F.
		S.......	+1.0664	—1.3	......	......	....	......	....	F.	F.
		N.......	+1.0650	+0.1	......	......	....	......	....	F.	F.
		S.......	+1.0652	—0.1	......	......	....	......	....	F.	J.
		Mean..	+1.0651								
T. B. M. 161 and 161a.	198.33	N.......	—0.2918	—1.8	1.2	......	179.0008	......	....	F.	J.
		S.......	—0.2953	+1.7	......	......	....	......	....	F.	J.
		Mean..	—0.2936								
T. B. M. 162.......	199.46	N.......	—2.3250	—4.2	1.1	......	176.6716	......	....	F.	J.
		S.......	—2.3325	+3.3	......	......	....	......	....	F.	J.
		N.......	—2.3290	—0.2	......	......	....	......	....	F.	J.
		S.......	—2.3303	+1.1	......	......	....	......	....	F.	J.
		Mean..	—2.3292								
T. B. M. 163 and 163a.	200.48	N.......	+0.2766	—2.2	1.5	......	176.9460	......	....	F.	J.
		S.......	+0.2721	+2.3	......	......	....	......	....	F.	J.
		Mean..	+0.2744								
T. B. M. 164.......	201.66	N.......	+1.3340	+1.2	0.8	......	178.2812	......	....	F.	F.
		S.......	+1.3365	—1.3	......	......	....	......	....	F.	F.
		Mean..	+1.3352								
T. B. M. 165.......	202.88	N.......	—1.6418	—0.2	0.1	......	176.6392	......	....	F.	F.
		S.......	—1.6422	+0.2	......	......	....	......	....	F.	F.
		Mean..	—1.6420								
T. B. M. 166 and 166a.	204.15	N.......	+0.2903	—2.9	0.9	.....	176.9266	......	....	F.	F.
		S.......	+0.2839	+3.5	......	......	....	......	....	F.	F.
		N.......	+0.2876	—0.2	......	......	....	......	....	F.	F.
		S.......	+0.2878	—0.4	......	......	....	......	....	F.	F.
		Mean..	+0.2874								
T. B. M. 168 and 168a.	205.70	N.......	+0.4104	+0.4	0.3	......	177.3374	......	....	F.	J.
		S.......	+0.4112	+0.4	......	......	....	......	....	F.	J.
		Mean..	+0.4108								
*U. S. P. B. M. 33..	205.77	N.......	+1.6909	+0.1	0.1	9.7	179.0284	+0.7	179.0291	....	F.
		S.......	+1.6912	—0.2	......	......	....	......	....	....	F.
		Mean..	+1.6910								
T. B. M. 170 and 170 a.	206.78	N.......	+0.6767	—0.1	0.1	......	178.0140	......	....	F.	J.
		S.......	+0.6764	+0.2	......	......	....	......	....	F.	J.
		Mean..	+0.6766								
T. B. M. 171 and 171 a.	208.17	N.......	+1.7992	—0.8	0.5	......	179.8124	......	....	F.	F.
		S.......	+1.7976	+0.8	......	......	....	......	....	F.	F.
		Mean..	+1.7984								
T. B. M. 172 and 172a.	208.99	N.......	+1.0681	—0.3	0.2	......	180.8802	.....	....	F.	F
		S.......	+1.0676	+0.2	......	......	....	......	....	F.	F
		Mean..	+1.0678								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
*U. S. P. B. M. 39	209.02	N	—0.0061	+0.1	0.1	9.7	180.8742	+0.7	180.8749		F.
		S	—0.0059	—0.1							F.
		Mean	—0.0060								
T. B. M. 173	209.68	N	—1.4397	—0.5	0.3		179.4400			F.	J.
		S	—1.4407	+0.5						F.	J.
		Mean	—1.4402								
*Zero of gauge at Rock Island Bridge.	209.96	N	—8.0315				171.4085				J.
*U. S. P. B. M. 40	209.80	N	+2.6728	+0.4	0.2	9.7	182.1132	+0.7	182.1139		J.
		S	+2.6735	—0.3							J.
		Mean	+2.6732								
*Astronomical post, Rock Island.	210.07	N	—0.4391	+0.1	0.1		179.0010	+0.7	179.0017		J.
		S	—0.4388	—0.2							J.
		Mean	—0.4390								
*H. W., 1880	209.96	N	—2.4233				177.0167				J.
T. B. M. 175	211.52	N	+0.6892	—1.3	0.9		180.1279			F.	J.
		S	+0.6866	+1.3						F.	J.
		Mean	+0.6879								
*U. S. P. B. M. 41	211.86	N	+3.1766	0.0	0.0	9.7	183.3045	+0.8	183.3053		F.
		S	+3.1767	—0.1							J.
		Mean	+3.1766								
T. B. M. 176 and 176*a*.	213.51	N	+1.5206	0.0	0.0		181.6485			F.	F.
		S	+1.5207	—0.1						F.	F.
		Mean	+1.5206								
T. B. M. 177	214.36	N	—1.3763	+1.9	1.2		180.2741			F.	F.
		S	—1.3726	—1.8						F.	F.
		Mean	—1.3744								
*U. S. P. B. M. 42	214.55	N	—0.7034	—0.6	0.4	9.8	179.5701	+0.7	179.5708		F.
		S	—0.7046	+0.6							F.
		Mean	—0.7040								
T. B. M. 178	215.15	N	+0.5246	+0.4	0.2		180.7991			F.	F.
		S	+0.5253	—0.3						F.	F.
		Mean	+0.5250								
T. B. M. 179	216.22	N	+0.1589	+1.6	1.1		180.9596			F.	J.
		S	+0.1621	—1.6						F.	J.
		Mean	+0.1605								
T. B. M. 180	217.28	N	+0.3918	—2.0	1.3		181.3494			F.	J.
		S	+0.3879	+1.9						F.	J.
		Mean	+0.3898								
T. B. M. 181	218.27	N	—1.4885	—0.1	0.0		179.8608			P.	J.
		S	—1.4886	0.0						P.	J.
		Mean	—1.4886								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T. B. M. 182	219.27	N	+1.2212	−0.7	0.5		181.0818			P.	J.
		S	+1.2198	+0.7						P.	J.
		Mean	+1.2205								
T. B. M. 183	220.17	N	+0.8765	+4.2	0.7		181.9620			F.	F.
		S	+0.8794	+1.3						F.	F.
		N	+0.8815	−0.8						F.	F.
		S	+0.8847	−4.0						F.	F.
		N	+0.8813	−0.6						P.	F.
		S	+0.8808	−0.1						P.	F.
		Mean	+0.8807								
T. B. M. 184 and 184a.	221.45	N	−1.6218	+4.1	1.1		180.3443			F.	F.
		S	−1.6169	−0.8						F.	F.
		N	−1.6142	−3.5						P.	F.
		S	−1.6179	+0.2						P.	F.
		Mean	−1.6177								
T. B. M. 185	222.34	N	−1.3258	−0.7	0.5		179.0178			P.	J.
		S	−1.3272	+0.7						P.	F.
		Mean	−1.3265								
T. B. M. 186 and 186a.	223.17	N	−0.2976	+0.2	0.4		178.7204			P.	J.
		S	−0.2973	−0.1						P.	J.
		Mean	−0.2974								
*U. S. P. B. M. 43	223.98	N	+2.7073	−0.1	0.0	10.1	181.4276	+0.7	181.4283	P.	J.
		S	+2.7072	0.0						P.	J.
		Mean	+2.7072								
T. B. M. 187	224.40	N	+2.3087	−0.3	0.2		181.0288			P.	J.
		S	+2.3081	+0.3						P.	J.
		Mean	+2.3084								
T. B. M. 188 and 188a.	225.12	N	+1.3826	−1.0	0.7		182.4104			P.	J.
		S	+1.3806	+1.0						P.	J.
		Mean	+1.3816								
*U. S. P. B. M. 44	225.93	N	−0.5884	−0.8	0.5	10.1	182.9980	+0.8	182.9988	P.	F.
		S	+0.5869	+0.7						P.	F.
		Mean	+0.5876								
T. B. M. 189 and 189a.	225.98	N	+0.1590	−1.0	0.6		182.5684			P.	F.
		S	+0.1571	+0.9						P.	F.
		Mean	+0.1580								
*U. S. P. B. M. 45. H. W., June, 1889.	226.51	N	−2.6251	−0.3	0.2	10.1	179.9430	+0.7	179.9437	P.	J.
		S	−2.6257	+0.3						P.	J.
		Mean	−2.6254								
T. B. M. 190 and 190a.	227.21	N	+1.6610	−2.1	1.4		184.2273			P.	F.
		S	+1.6568	+2.1						P.	F.
		Mean	+1.6589								
T. B. M. 191 and 191a.	228.46	N	−0.9600	−2.4	1.6		183.2649			P.	J.
		S	−0.9647	+2.3						P.	J.
		Mean	−0.9624								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T. B. M. 192 and 192*a*.	230.37	N.......	+0.0750	−1.0	0.7	......	183.3389	......	....	P.	J.
		S	+0.0729	+1.1	......	......	....	......	....	P.	J.
		Mean..	+0.0740								
T. B. M. 192A.....	232.47	N.......	+1.5033	+0.9	0.6	......	184.8431	......	....	P.	F.
		S	+1.5051	−0.9	......	......	....	......	....	P.	F.
		Mean..	+1.5042								
*U. S. P. B. M. 46 .	232.66	N.......	−3.0028	+0.5	0.3	10.4	181.8408	+0.8	181.8416	P.	J.
		S	−3.0018	−0.5	......	......	....	......	....	P.	J.
		Mean..	−3.0023								
T. B. M. 193 and 193*a*.	233.31	N.......	−0.5128	+0.8	0.5	......	184.3311	......	....	P.	F.
		S	−0.5113	−0.7	......	......	....	......	....	P.	F.
		Mean..	−0.5120								
T. B. M. 194.......	234.07	N.......	−1.3869	−1.4	0.9	......	182.9428	......	....	P.	J.
		S	−1.3897	+1.4	......	......	....	......	....	P.	J.
		Mean..	−1.3883								
*U. S. P. B. M. 47..	234.24	N.......	+0.0077	0.0	0.0	10.4	182.9505	+0.8	182.9513	....	J.
		S	+0.0077	0.0	......	......	....	......	....	....	J.
		Mean..	+0.0077								
T. B. M. 195.......	235.46	N.......	+0.0988	0.0	0.0	......	183.0416	......	....	P.	J.
		S	+0.0989	−0.1	......	......	....	......	....	P.	J.
		Mean..	+0.0988								
*U. S. P. B. M. 48..	235.47	N.......	+0.3589	......	......	10.4	183.4005	+0.8	183.4013	....	J.
*P. B. M. 40, Mackenzie.	235.52	N.......	−0.4690	......	......	......	182.5726	+0.8	182.5734	....	J.
*U. S. P. B. M. 49..	235.66	N.......	+2.1609	......	......	10.4	185.2025	+0.8	185.2033	....	F.
*H. W., June 25, 1880.	235.62	N.......	−0.8818	......	......	......	182.1598	......	....	....	F.
*H. W., Oct., 1881.	235.62	N.......	−1.0596	......	....	......	181.9820	......	....	....	F.
T. B. M. 196 and 196*a*.	238.34	N.......	+2.4776	+1.6	1.1	......	185.5208	......	....	P.	F.
		S	+2.4808	−1.6	......	......	....	......	....	P.	F.
		Mean..	+2.4792								
T. B. M. 197.......	239.71	N.......	+3.1306	−5.0	0.8	......	188.6464	......	....	P.	F.
		S	+3.1219	+3.7	......	......	....	......	....	P.	F.
		N.......	+3.1265	−0.9	......	......	....	......	....	F.	F.
		S	+3.1263	−0.7	......	......	....	......	....	F.	F.
		N.......	+3.1244	+1.2	......	......	....	......	....	P.	F.
		S	+3.1242	+1.4	......	......	....	......	....	P.	F.
		Mean..	+3.1256								
T. B. M. 198 and 198*a*.	241.35	N.......	+1.1282	−2.1	1.4	......	189.7725	......	....	P.	F.
		S	+1.1240	+2.1	......	......	....	......	....	P.	F.
		Mean..	+1.1261								
T. B. M. 199......	242.60	N.......	−2.4735	−0.3	0.2	......	187.2987	......	....	P.	J.
		S.......	−2.4740	+0.2	......	......	....	......	....	P.	J.
		Mean ..	−2.4738								

Results of precise leveling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T. B. M. 200	243.76	N	—0.5731	—0.5	0.8	......	186.7251	......	....	P.	J.
		S	—0.5740	+0.4	......	......	....	......	....	P.	J.
		Mean	—0.5736								
*U. S. P. B. M. 50	244.66	N	—5.6715	+0.1	0.1	10.6	181.0537	+0.7	181.0544	P.	F.
		S	—5.6712	—0.2	......	......	....	......	....	P.	F.
		Mean	—5.6714								
*P. B. M. 39, Mackenzie.	....	N	+0.0154	......	......	10.6	181.0691	+0.7	181.0698	....	F.
*H. W., 1870	....	N	+2.0336	......	......	......	183.0873	......	....	....	F.
*U. S. P. B. M. 51	244.13	N	+0.7885	......	......	10.6	187.5136	+0.9	187.5145	....	J.
T. B. M. 201 and 201a.	244.50	N	+2.4419	+0.7	0.4	......	189.1677	......	....	P.	J.
		S	+2.4432	—0.6	......	......	....	......	....	P.	J.
		Mean	+2.4426								
T. B. M. 202 and 202a.	246.58	N	+0.6109	—1.6	1.1	......	189.7770	......	....	F.	J.
		S	+0.6077	+1.6	......	......	....	......	....	F.	J.
		Mean	+0.6093								
T. B. M. 203 and 203a.	247.58	N	+0.4328	+0.2	0.1	......	190.2100	......	....	F.	J.
		S	+0.4332	—0.2	......	......	....	......	....	F.	J.
		Mean	+0.4330								
T. B. M. 204 and 204a.	248.59	N	+0.9696	+1.3	0.9	......	191.1809	......	....	F.	F.
		S	+0.9722	—1.3	......	......	....	......	....	F.	F.
		Mean	+0.9709								
T. B. M. 205	249.44	N	+1.2849	—0.5	0.3	......	192.4653	......	....	F.	F.
		S	+1.2839	+0.5	......	......	....	......	....	F.	F.
		Mean	+1.2844								
T. B. M. 206 and 206a.	251.41	N	—0.0492	+0.6	0.4	......	192.4167	......	....	F.	F.
		S	—0.0481	—0.5	......	......	....	......	....	F.	F.
		Mean	—0.0486								
T. B. M. 207	252.79	N	—3.0692	—1.8	1.2	......	189.3457	......	....	F.	J.
		S	—3.0729	+1.9	......	......	....	......	....	F.	J.
		Mean	—3.0710								
T. B. M. 208 and 208a.	254.24	N	—1.6983	—0.5	0.3	......	187.6469	......	....	F.	J.
		S	—1.6993	+0.5	......	......	....	......	....	F.	J.
		Mean	—1.6988								
B. M. 63, Hennepin Canal.	256.27	N	—4.9627	—0.7	0.4	10.8	182.6835	+0.8	182.6843	F.	J.
		S	—4.9640	+0.6	......	......	....	......	....	F.	J.
		Mean	—4.9634								
*B. M. 64, Hennepin Canal.	256.82	N	—0.0691	+0.1	0.1	10.8	182.6145	+0.8	182.6153	F.	J.
		S	—0.0688	—0.2	......	......	....	......	....	F.	J.
		Mean	—0.0690								
T. B. M. 209 and 209a.	258.53	N	+2.3604	—0.4	0.3	......	185.0435	......	....	F.	F.
		S	+2.3596	+0.4	......	......	....	......	....	F.	F.
		Mean	+2.3600								

Results of precise levling—Continued.

KEOKUK, IOWA, TO FULTON, ILL.—Continued.

Bench.	Distance.	Direction.	Difference of elevation.	V.	r.	R.	Elevation.	Rod correction.	Corrected elevation.	Support.	Observer.
	Km.		*M.*	*Mm.*	*Mm.*	*Mm.*	*M.*	*Mm.*	*M.*		
T. B. M. 210	259.57	N	−1.7114	+0.6	0.4	.....	183.3327	......	....	F.	F.
		S	−1.7101	−0.7	......	......	....	......	....	F.	F.
		Mean	−1.7108								
*U. S. P. B. M. 52	260.57	N	+4.3659	−0.5	0.3	10.8	187.6981	+0.9	187.6990	F.	F.
		S	+4.3650	+0.4	......	......	....	......	....	F.	F.
		Mean	+4.3654								
*P. B. M. 37, Mackenzie.	....	N	+1.1872	......	......	10.8	184.5199	+0.8	184.5207	....	F.
*H. W., 1870	....	N	+0.9345	......	......	......	184.2672	......	....	....	F.
*H. W., 1880	....	N	+1.0932	......	......	......	184.4259	......	....	....	F.
T. B. M. 211 and 211*a*.	260.22	N	+0.4099	+0.8	0.5	......	183.7434	......	....	F.	F.
		S	+0.4115	−0.8	......	......	....	......	....	F.	F.
		Mean	+0.4107								
T. B. M. 212	261.22	N	+1.1849	+1.7	1.2	......	184.8800	......	....	F.	J.
		S	+1.1884	−1.8	......	......	....	......	....	F.	J.
		Mean	+1.1866								
*U. S. P. B. M. 53	261.29	N	+3.7203	−0.3	0.2	......	188.6000	+0.9	188.6009	F.	J.
		S	+3.7198	+0.2	......	......	....	......	....	F.	J.
		Mean	+3.7200								
T. B. M. 213 and 213*a*.	262.24	N	−0.7346	−3.4	1.0	......	184.1420	......	....	F.	J.
		S	−0.7417	+3.7	.....	......	....	......	....	F.	J.
		N	−0.7377	−0.3	.....	......	....	......	....	F.	J.
		S	−0.7379	−0.1	......	......	....	......	....	F.	J.
		Mean	−0.7380								
U. S. P. B. M. 54	263.33	N	−1.8437	+0.5	0.4	10.9	182.2988	+0.7	182.2995	P.	F.
		S	−1.8426	−0.6	......	......	....	......	....	P.	F.
		Mean	−1.8432								
T. B. M. 214 and 214*a*.	265.22	N	+3.4398	+0.5	0.3	......	185.7391	......	....	P.	F.
		S	+3.4408	−0.5	......	......	....	......	....	P.	F.
		Mean	+3.4403								
U. S. P. B. M. 55	266.94	N	−2.4423	+0.3	0.2	11.0	183.2971	+0.7	183.2978	P.	F.
		S	−2.4418	−0.2	......	......	....	......	....	P.	F.
		Mean	−2.4420								
U. S. P. B. M. 56	266.99	N	+0.3828	+0.2	0.1	11.0	183.6801	+0.8	183.6809	....	F.
		S	+0.3832	−0.2	......	......	....	......	....	....	F.
		Mean	+0.3830								

DESCRIPTION OF PERMANENT BENCH-MARKS BETWEEN CARROLLTON, LA., AND BILOXI MISS.

U. S. C. S. B. M. No. 1 is a small cross (+) cut on iron sill of walled-up door, near northwest corner of seventh district Babcock engine-house, Carrollton, La. Elevation, 9^{m}.0272.

HAMPSON BENCH (WILLIAMS).—The old Hampson Bench is a spike in N. W. corner of N. O. and C. R. R. machine-shop at Carrollton, La. It is between the 19th and 20th courses of bricks below the window-sill, and about six inches (6″) below the surface of the ground. Elevation, 8^{m}.8292.

HAMPSON BENCH (*Re-established by Major Howell*) is a spike in the N. W. corner of N. O. and C. R. R. machine-shop at Carrollton, La. It is between the 21st and 22d courses of brick below the window-sill. Elevation, 8^{m}.6551.

B. M. 3 (*Ripley*, 1875) is the top of a broken spike driven into the north face of the car-house of the N. O. and C. R. R. It is two feet (2′) west of west side of door, on a level with the course of bricks upon which the door-sill rests. Elevation, 9^{m}.7752.

B. M. 4 (*Ripley*, 1875) is the top of a ship-spike driven in the north side of the machine-shop of the N. O. and C. R. R., 0.2 ft. from N. W. corner. The spike is driven between the bricks, 37 courses from top of window casing. Elevation, 9^{m}.5181.

B. M. 5 (*Burney*, 1875), is mark $\overset{\wedge}{\text{U. S. E.}}$ cut on the west end of iron sill of the north door of the N. O. and C. R. R. depot. Elevation 9^{m}.0303.

U. S. P. B. M. "CARROLLTON" is the center of small hole in center of copper bolt, leaded horizontally in north face of masonry of northwest corner pillar of old court-house, at Carrollton, La. The bolt is in the middle, about 0.03 ft. from water table of pillar and about 2.5 ft. above the ground. The letters $\overset{\text{U S}}{\underset{\text{P B M}}{\odot}}$ are cut near the bolt. Elevation, 9^{m}.1478.

CITY B. M. x x STONE is top of granite marking stone set in ground, in line of trees, on the west side of Carrollton ave., about half-way between 3d st. and Zimple st., Carrollton, La., The stone is marked thus: $\boxed{\begin{array}{c}\text{X X M B}\\ \text{JUNE}\\ +\\ \text{1874.}\end{array}}$ The mark + denotes the point where the rod was held. Elevation, 7^{m}.7655.

CITY STONE (*corner Washington and Carrollton avenues*). This stone is set at southeast corner of crossing of Washington and Carrollton avenues, near New Orleans, La. Elevation, 7^{m}.7633.

U. S. P. B. M. 1 is a copper bolt leaded vertically in the top of the northwest portion of draw-pier of bridge, called the "White Bridge," crossing the new canal, on the Carrollton road, near New Orleans, La. Elevation, 6^{m}.9402.

City Stone "Halfway House" is a granite marking-stone set in ground on west side of navigable canal (New Basin), near Metairie Ridge Bridge, between the Halfway House and the gate to Metairie Cemetery. It is said to be the line-stone of the Orleans and Metairie Parishes of New Orleans, La. The stone is marked on top with a cross. Elevation, 7^{m}.9870.

Bench-mark "Height of Metairie Ridge" is a granite marking-stone set in ground 12 ft. southeast from southeast abutment of Lake Bridge, on east side of canal (New Basin). The bridge crosses the canal (New Basin) opposite Toney's House, West End, near New Orleans, La. The top of the stone is 8″ x 13″, and is marked $\boxed{\begin{array}{c}\text{BENCHMARK}\\ \text{HEIGHT OF}\\ \text{METAIRIE}\\ \text{RIDGE.}\end{array}}$ Elevation, 7^{m}.6753.

Bench-mark (near Lake House, West End, La.). This bench-mark is the top of a stone, set in ground between the Lake House and Toney's House. It is on line with front fence of Toney's House, 160 ft. from center of canal and about 30 ft. from road, crossing the canal on the Lake Bridge, at West End, near New Orleans, La. Elevation, 7^{m}.1244.

U. S. P. B. M. 2 is the center of a copper bolt leaded horizontally in the northwest face of the south one of two brick abutments, at northwest end of draw-bridge across the Bayou St. John, on the Esplanade Road, New Orleans, La. The letters $\overset{\text{U S}}{\underset{\text{P B M}}{\odot}}$ are cut near the bolt. Elevation 9^{m}.1593.

U. S. P. B. M. 3 is center of copper bolt leaded horizontally in the east face of middle brick gate-post of Gentilly gate on east side of Fair Grounds, New Orleans, La. The bolt is leaded in the middle brick of the fifth (5th) course above the surface of the ground. The letters U⊙S are cut near the bolt. Elevation, $7^{m}.6746$.

U. S. P. B. M. 4 is the center of a copper bolt leaded horizontally in wall of Fort Macomb, Chef Menteur, La., on right-hand side (as you go in) of entrance. There is a moat around the wall. The letters $\overset{\text{U S}}{\underset{\text{P B M}}{18\odot 82}}$ are cut about the bolt. Elevation, $8^{m}.5427$.

U. S. P. B. M. 5 is a copper bolt leaded vertically near center of old draw-bridge pier, just north of iron truss bridge over the Rigolets, near Rigolets Station, on the N. O. and M. R. R., La. Elevation, $6^{m}.9509$.

U. S. P. B. M. 6 is a copper bolt leaded in top of marking-stone set to within 0.25 ft. of its top, in high point of ground just east of East Pearl River, in Miss. It is 200 meters east of the eastern pier of iron truss bridge over the East Pearl River, on the N. O. and M. R. R., and 27.2 meters south of the center of main railroad track, by fence in front of land of Mrs. Sarah Selph. Elevation, $9^{m}.5649$.

U. S. P. B. M. 7 is center of cross-cut in top of marking-stone, marked U. S., set in ground just north of north fence of house lot of Pat. Ferril, near Claiborne Station, on N. O. and M. R. R., Miss. It is 18 meters south of center of main track, 12 meters east of east end of station-house, and 36 meters west of west end of wood-shed of N. O. and M. R. R.; the distances, 12 meters and 36 meters, being measured parallel to railroad track. Elevation, $7^{m}.6028$.

U. S. P. B. M. 8 is top of marking-stone, marked U. S., set in ground in northwest corner of small yard, in front of large yard, on which the section-house at Toulmé Station, N. O. and M. R. R., Miss., is situated. Stone is about 10 meters south of center of main track. Elevation, $9^{m}.2944$.

U. S. P. B. M. 9 is top of marking-stone, marked U. S., set within the southeast corner of fence surrounding the land of Henderson Winfield, near Waveland Station, N. O. and M. R. R., Miss. The corner is at the intersection of Waveland road and lane, between the lands of Mr. Shaw and Mr. Winfield. Stone is about 32 meters from southwest corner of station-house. Elevation, $11^{m}.0606$.

U. S. P. B. M. 10 is center of copper bolt leaded horizontally in face of southern brick wall of vestibule of Catholic church at Bay Saint Louis (Shieldsboro'), Miss. It is about half way between side entrance of vestibule and main front wall, and about 1 meter above the ground. Elevation, $13^{m}.5133$.

U. S. P. B. M. 11 is a copper bolt leaded in top of marking-stone, marked U. S., set in ground, by fence, and near northeast corner of fence of southwest plot of land, at intersection of N. O. and M. R. R. track and Front street, Bay Saint Louis, Miss. It is about 12 meters south of center of track, and 514 meters west of west end of bridge over Bay St. Louis. Elevation, $12^{m}.8623$.

U. S. P. B. M. 12 is copper bolt leaded in top of marking-stone, marked U. S., set in ground within northwest corner of fence surrounding plot of ground on which the tool-house of N. O. and M R. R. section-house No. 9 is situated, at Henderson's Point, Miss. Stone is about 32 meters west of west side of house, and 8 meters south of center of track. Elevation, $9^{m}.3391$.

U. S. P. B. M. 13 is copper bolt leaded in top of marking-stone, marked U. S., set in ground between pump-house and water-tank at Pass Christian Station, N. O. and M. R. R., Miss. It is a little inside of north line of pump-house and tank, and about 3 meters from west side of pump-house. Pump-house is about 9 meters south of track. Elevation, $9^{m}.7359$.

U. S. P. B. M. 14 is top of copper bolt leaded in top of marking-stone set in ground directly opposite the New Orleans 62-mile post and 8 meters north of center of track of N. O. and M. R. R. Elevation, $15^{m}.7654$.

U. S. P. B. M. 15 is top of marking-stone set in ground 24 meters north of center of track, about 873 meters east of New Orleans 65-mile post, and about 639 meters west of New Orleans 66-mile post, on the N. O. and M. R. R. Three pine trees, each marked with five narrow blazes, are near the stone. Elevation, $14^{m}.0706$.

U. S. P. B. M. 16 is center of copper bolt, leaded horizontally in center of fifth (5th) brick of the fifteenth (15th) course above water-table, in the west wall of jail at Mississippi City, Miss. The bricks are counted from northwest corner of building. It is marked $\overset{\text{U S}}{\underset{\text{B M}}{\odot}}$ Elevation, $12^{m}.7428$.

U. S. P. B. M. 17 is copper bolt leaded in top of marking-stone set in ground near west end of depot platform, and 11 meters south of center of track at Beauvoir Station, N. O. & M. R. R., Miss. Elevation, $14^{m}.2322$.

U. S. P. B. M. 18 is center of copper bolt leaded horizontally in center of second (2nd) brick of the fourteenth (14th) course above sidewalk, in east wall, near southeast corner of brick building on southwest corner of Back Bay road (or Mule street) and Jackson street, Biloxi, Miss. Elevation, $13^{m}.1006$.

U. S. P. B. M. 19 is copper bolt leaded in top of marking-stone marked U. S., set in ground 30 meters south of center of track and 255 meters west from west end of Biloxi Bay bridge, on the N. O. & M. R. R. Pine trees near the stone are marked with five narrow blazes. Elevation, 8^{m}.1680.

U. S. P. B. M. 20 is copper bolt leaded in top of marking-stone marked U. S., set in ground 4 meters north of center of track and 114 meters west from west end of Biloxi Bay bridge, on the N. O. & M. R. R. Elevation, 8^{m}.5125.

U. S. P. B. M. 21 is top of copper bolt leaded in northern portion of concrete draw-bridge pier of Biloxi Bay bridge, on the N. O. & M. R. R. The bolt is set about half way between cog-wheel and extreme north point of iron casing of concrete. Letters U. S. cut near the bolt. Elevation, 6^{m}.7111.

DESCRIPTION OF PERMANENT BENCH-MARKS BETWEEN GRAFTON, ILL., AND CAIRO, ILL.

U. S. P. B. M. 1 is copper bolt in top of stone in ground in woods on Calhoun Point, at mouth of Illinois River. It is 60 meters from edge of woods on Illinois River, and 150 meters from edge of woods on Mississippi River. Elevation, 134^{m}.5101.

U. S. P. B. M. 2 is top of copper bolt in top of stone in ground in woods at mouth of Illinois River on left bank, 157 meters back from river, 4 meters east of fence, 15 meters south of road, 2,100 meters above Catholic Church in Grafton, Ill., and within triangle formed by three pecan trees. Elevation, 136^{m}.3645.

U. S. P. B. M. 3 is copper bolt in top surface of doorstep of Catholic Church, Grafton, Ill. It is 22 centimeters from front of step, and 13 centimeters from north jamb. Elevation, 139^{m}.3116.

U. S. P. B. M. 4 is copper bolt in east end of doorstep of eastern door in Allen's brick building, adjoining Grafton Flouring Mills, Grafton, Ill. It is 104 millimeters from front surface of step. Elevation, 142^{m}.0719.

U. S. P. B. M. 5 is copper bolt leaded in the natural rock on side of bluff above high-water mark. It is 450 meters below flour mill at Jersey Landing, Ill., and about 4 miles below Grafton, Ill. The letters U. S. P. B. M. are cut in the rock near the copper bolt. Elevation, 141^{m}.4305.

U. S. P. B. M. 6 is copper bolt leaded vertically in the natural flat rock; top of rock flush with surface of ground. It is 5,600 meters below flour mill at Jersey Landing, Ill. It lies near high-water mark and about 9 meters west of the mouth of small ravine which comes out of valley facing the "Eagle's Nest." Elevation, 135^{m}.0339.

U. S. P. B. M. 7 is copper bolt in natural rock on hillside, in woods 19 meters above high-water mark, and 3,150 meters below mouth of Piasa Creek. The letters U. S. P. B. M. are cut near bolt. Elevation, 143^{m}.7181.

U. S. P. B. M. 8 is copper bolt leaded vertically in east end of water-table, on the south side of the Alton water works building in sixth window from corner, Alton, Ill. The letters U. S. cut near the bolt. Elevation, 136^{m}.9468.

U. S. P. B. M. 9 is copper bolt leaded vertically in south end of doorstep, in north west corner of German Catholic Church in Alton, Ill. Elevation, 154^{m}.4612.

U. S. P. B. M. 10 is top of copper bolt in stone post in ground in woods on land of —. —. Gringering, about three hundred meters east of his house, and 5 miles below Alton, Ill. It is about 500 meters from river bank. Elevation, 136^{m}.0457.

U. S. P. B. M. 11 is top of copper bolt in stone in ground in woods 450 meters back from triangulation station Gillen, 2 meters north of honey-locust tree, about 10 meters north of road, and about 11 miles below Alton, Ill. There is a road leading back from river past this bench-mark. Elevation, 132^{m}.2312.

U. S. P. B. M. 12 is top of copper bolt in stone in ground in corner of grove 20 meters west of Columbia road, 12.8 miles above steel railroad bridge at St. Louis, Mo. It is on land of —. —. Chambers, about opposite lower end of Wilson's Island No. 5. Elevation, 145^{m}.6611.

U. S. P. B. M. 13 is top of copper bolt in top of stone in ground in small grove on east side of Baden and Saint Louis street-car track, 6.4 miles above the railroad bridge at Saint Louis, Mo. It is 110 meters south of northern terminus Baden street-car track, and 37 meters east of same. Elevation, 137^{m}.6447.

U. S. P. B. M. 14 is small hole in center of copper bolt leaded horizontally in third course of stones on north side of western engine-room of Saint Louis water works, Saint Louis, Mo. It is 147 centimeters west of west coping to main entrance to building. The letters U. S. P. B. M. are cut near the bolt. Elevation, 136^{m}.1201.

U. S. P. B. M. 15 is small hole in copper bolt leaded horizontally in the west pier of arch No. 4, on east side of pier of Saint Louis steel bridge, at Saint Louis, Mo. It is 6.14 meters south of north end of pier and 14 centimeters above top course of granite. The letters U. S. are cut in the granite below the bench-mark. Elevation, 133^{m}.0938.

U. S. P. B. M. 16 is top of copper bolt leaded vertically in east end of doorstep of second door from northeast corner of brick saloon adjoining "Saint Louis Park" at junction of Jefferson avenue and Carondelet road, Saint Louis, Mo. Bench-mark is 29.5 centimeters from front face and 10 centimeters west of buttress adjoining door-step. Elevation, 159^{m}.3461.

U. S. P. B. M. 17 is top of copper bolt leaded vertically in north end of north door-step of E. Mueller's store, north of northeast corner of Main and Franklin streets, Carondelet, Mo. Elevation, 138^{m}.6820.

U. S. P. B. M. 18 is center of copper bolt leaded horizontally in water-table in northeast corner of guard-house, at Jefferson Barracks, Mo. Elevation, 156^{m}.8992.

U. S. P. B. M. 19 is center of copper bolt leaded horizontally in east face of stone in fourth course from top in east end of culvert at Cliff Cave, Mo., on Iron Mountain Railroad. Elevation, 126^{m}.1949.

U. S. P. B. M. 20 is top of copper bolt leaded vertically in upper surface of third stone from top, in south-west retaining wall of arched culvert, over White House Creek, on Iron Mountain Railroad. Elevation, 131^{m}.0967.

U. S. P. B. M. 21 is top of copper bolt leaded vertically in top stone directly over keystone of arch on north side of arched culvert, 650 meters below Jefferson Station, Mo., on Iron Mountain Railroad. The letters U. S. P. B. M. are cut near the bolt. Elevation, 130^{m}.0469.

U. S. P. B. M. 22 is top of copper bolt leaded vertically in southern abutment to southern approach to railroad bridge on Iron Mountain Railroad at Kimmswick, Mo. Elevation, 130^{m}.6901.

U. S. P. B. M. 23 is center of copper bolt leaded horizontally in east face of stone in northeast corner of southern pier of railroad bridge, 400 meters below station-house at Sulphur Springs, Mo. Elevation, 129^{m}.3103.

U. S. P. B. M. 24 is center of copper bolt leaded horizontally in natural rock in overhanging bluff 1,000 meters below station-house at Illinois Station, Mo. This is the first bluff that is seen from water's edge, standing opposite point where Iron Mountain Railroad leaves Mississippi River. Elevation, 131^{m}.7525.

U. S. P. B. M. 25 is top of copper bolt leaded vertically in Cornice Rock, about 2 meters from river edge of rock, and about 160 meters south of foot of Cornice Island, and 1,000 meters south of mouth of Platin Rock Creek, Jefferson Co., Mo. Elevation, 123^{m}.6392.

U. S. P. B. M. 26 is top of copper bolt leaded vertically in top of Robber's Rock, on north side, and 1,736 meters above Rush Tower, Mo. Robber's Rock is large sandstone on beach, and is plainly visible for three-fourths of a mile up or down the river. Elevation, 124^{m}.6578.

U. S. P. B. M. 27 is center of copper bolt leaded horizontally in limestone wall (natural rock), at Rush Tower, Mo., and 11 meters from post-office building. Elevation, 126^{m}.6790.

U. S. P. B. M. 28 is top of copper bolt leaded vertically in large limestone bowlder on beach, 1,000 meters above Brickey's Mill, Cliff P. O., Ste. Genevieve Co., Mo. This beach is a little lower than extreme high-water mark. Elevation, 121^{m}.5487.

U. S. P. B. M. 29 is center of copper bolt leaded horizontally in limestone wall (natural rock) at end of bluff about 4 meters north of a red oak tree, about 30 meters north of——— Maple's farm-house and three miles below Cliff P. O., Ste. Genevieve Co., Mo. This bench-mark in about one foot above surface of ground at base of bluff and is about 8 meters above high water-mark. Elevation, 131^{m}.0374.

U. S. P. B. M. 30 is center of copper bolt leaded horizontally in natural rock 1,580 meters above White Sand Depot Landing, Ste. Genevieve Co., Mo. It is about 250 meters north of southern end of bluff. The letters U. S. P. B. M. are cut near the bolt. Elevation, 124^{m}.6871.

U. S. P. B. M. 31 is center of copper bolt leaded horizontally in natural rock wall 14 meters north of a spring at Limestone Point, Ste. Genevieve Co., Mo., and is about 2¼ miles above Ste. Genevieve, Mo. The letters U. S. P. B. M. are cut around the bolt. Elevation, 128^{m}.9043.

U. S. P. B. M. 32 is top of copper bolt leaded vertically in west end of doorstep on south side of Rozier's warehouse, southwest corner Main and Washington streets, Ste. Genevieve, Mo. Elevation, 125^{m}.1543.

U. S. P. B. M. 33 is center of copper bolt leaded horizontally in south side at southeast corner of public school building in Ste. Genevieve, Mo., four inches from corner in fifth course of stones below the bricks. The letters U. S. P. B. M. are cut near the bolt. Elevation, 128^{m}.3151.

U. S. P. B. M. 34 is center of copper bolt leaded horizontally in east face of large corner-stone of engine-house of Quarrytown Grindstone Works, at Quarrytown, Mo., three miles below Ste. Genevieve, Mo. The letters U. S. P. B. M. are cut near the bolt. Elevation, 123^{m}.2542.

U. S. P. B. M. 35 is center of copper bolt leaded horizontally in west end of water-table in southwest corner of storehouse belonging to E. S. Lanbaugh, on northeast corner of Second and Walnut streets, Ste. Mary's, Mo. The bolt is countersunk about 5 millimeters in the stone. The letters U. S. P. B. M. are cut near the bolt. Elevation, 124^{m}.6617.

U. S. P. B. M. 36 is center of copper bolt leaded horizontally in southwest corner of Martin Roundstone's ice-house on east side of Walnut street, Ste. Mary's, Mo. The letters U. S. P. B. M. are cut near the bolt. The bolt is in fifth course of stones from bottom. Elevation, $126^{m}.7787$.

U. S. P. B. M. 37 is top of copper bolt leaded vertically in stone post set in ground in woods about 4 miles below Ste. Mary's, Ste. Genevieve Co., Mo. It is 990 meters back from river and 24 meters west of lane running south from river road. Lane turns off from river road in vicinity of John Lawrence's house. This bench-mark is S. 40° W. from farm-house, 7 meters N. 75° W. from ash tree, and 4½ meters N. 52° E. from box-elder tree. Elevation, $118^{m}.1124$.

U. S. P. B. M. 38 is horizontal copper bolt in water-table of drug store northeast corner of Schuchert's Block, Chester, Ill. Elevation, $122^{m}.0907$.

U. S. P. B. M. 39 is horizontal copper bolt in front face of Cole Brothers' stone elevator, 1.32 meters east of the southwest corner and the same distance above the ground, 1,240 meters below Chester, Ill. Elevation, $122^{m}.2673$.

U. S. P. B. M. 40 is top of copper bolt in stone monument set in southeast corner of woods 576 meters back from a long lane just west of large wheatfield from turn of road, 40 meters north of farm-house of Marcus Peto. It is 2 meters south of elm tree 4 feet in diameter, 12 meters west from hackberry tree 18 inches in diameter, and 200 meters northwest of house not occupied. Elevation, $118^{m}.0519$.

U. S. P. B. M. 41 is top of copper bolt in stone in ground 50 meters south of end of lane, 1 meter from fence, 1,420 meters back from river at Bois Brulé P. O., Perry Co., Mo. Elevation, $116^{m}.5760$.

U. S. P. B. M. 42 is center of copper bolt set horizontally in vertical face of natural rock at upper extremity of bluff 643 metres below Grand Eddy post-office, Perry Co., Mo. It is about 3½ meters below upper end of U. S. water-gauge, and 14 meters below extreme upper point of the bluff rocks. The letters U. S. P. B. M. are cut in the rock near the bolt. Elevation, $119^{m}.4255$.

U. S. P. B. M. 43 is center of copper bolt leaded horizontally in a large rock in the woods about 4 miles below Grand Eddy, Perry Co., Mo. It is 740 meters below a house, 175 meters back from the river, and 30 meters back from edge of timber, and at the upper end of a stretch of prairie land which extends down to 76 landing. Elevation, $118^{m}.7714$.

U. S. P. B. M. 44 is top of copper bolt leaded vertically in a large bowlder, 10 feet by 10 feet by 6 feet, 6 meters from edge of bank, 17 meters above second gate above farm-houses of Napoleon Gill, 100 meters above barn on Cape Cinque Hommes, Perry Co., Mo., and 3¾ miles above Wittenberg, Mo. Elevation, $118^{m}.5512$.

U. S. P. B. M. 45 is center of copper bolt leaded horizontally in stone foundation-wall of Wittenberg Flouring-Mill, at Wittenberg, Mo., on side facing the river between the ground-floor door and down-river corner of mill. Elevation, $116^{m}.5964$.

U. S. P. B. M. 46 is center of copper bolt leaded horizontally in east face of rock, 2 meters east of road, 400 meters below Wittenberg, Mo. It is situated between the houses of Denny and Tucker, 23 meters from the former and 31 meters above the latter's house. It is 11 meters below Denny's shop and 29 meters above Tucker's barn. Elevation, $116^{m}.4716$.

U. S. P. B. M. 47 is top of copper bolt leaded vertically in the point of rocks 95 meters below "Tower Rock," Perry Co., Mo., and opposite the upper end of Grand Tower, Ill. It is 15 meters east of an iron bolt leaded vertically in the rock and marked "U. S. 53." The letters U. S. P. B. M. are cut near the copper bolt. Elevation, $111^{m}.0031$.

U. S. P. B. M. 48 is center of copper bolt leaded horizontally in face of rock at Birmingham Point, Perry Co., Mo. It is 813 meters above the mouth of Apple Creek, and 28½ meters above a scrubby, gnarled sycamore tree growing in the rocks. The rocks here are conglomerate in horizontal strata, and from the river present the appearance of a stairway. The letters U. S. P. B. M. are cut near the bolt in the rock. It is about 30 meters above a living spring, which comes up out of the gravel just below the strata of rock. Elevation, $110^{m}.0317$.

U. S. P. B. M. 49 is top of copper bolt leaded vertically in the bluff rock 3,655 meters below mouth of Apple Creek, Cape Girardeau Co., Mo. In front of this bench-mark are three very large rocks standing out from the bluff and partly detached therefrom. Elevation, $110^{m}.2011$.

U. S. P. B. M. 50 is center of copper bolt leaded horizontally in natural rock in river bluff 712 meters below rock called "The Devil's Tea Table," in Cape Girardeau Co., Mo. Elevation, $110^{m}.2257$.

U. S. P. B. M. 51 is center of copper bolt leaded in the steeply-inclined face of the last reliable ledge of rocks of the chain extending south from Moccasin Springs, Mo., and at the point where the bluffs begin to recede from the river 2,500 meters above Bainbridge Creek. The letters U. S. are cut in the rock. Elevation, $109^{m}.1341$.

U. S. P. B. M. 52 is a horizontal copper bolt set in vertical face of ledge of rocks 35 centimeters thick. The bolt is 1.2 meters above the ground, is 775 meters below Henry

Shineman's house and 565 meters above the foot of the bluffs. These bluffs are 4 miles above north end of Cape Rock, Cape Girardeau Co., Mo., ¼ mile from river, and on land of Elisha Sheppard's heirs. Elevation, 110^{m}.5744.

U. S. P. B. M. 53 is center of horizontal copper bolt, set in vertical face of ledge, just below a ravine at the lower end of Cape Rock. Its elevation is about high water. Elevation, 108^{m}.7640.

U. S. P. B. M. 54 is a horizontal copper bolt in the outer vertical face of stone step, which extends under buttress at the northeast corner, second entrance from the north, to Marble City Hotel, on Water street, Cape Girardeau, Mo. Elevation, 111^{m}.7495.

U. S. P. B. M. 55 is horizontal copper bolt in vertical face of good homogeneous hard rock, just below and near the southeast corner of St. Vincent's College, about 45 meters west of river, in south part of Cape Girardeau, Mo. Elevation, 114^{m}.7730.

U. S. P. B. M. 56 is horizontal brass key, in vertical face of solid rock of fairly hard homogeneous sandstone, or granite, very white when cut. Ledge forms bank of river, and is at lower end of Cape Girardeau, in front of St. Vincent College. It is about 35 meters east of railroad track. Elevation, 107^{m}.1247.

U. S. P. B. M. 57 is center of horizontal copper bolt, set in smooth vertical face, in ledge of blue, or gray, limestone, at its upper, or western, extremity, on the land of the Taylor estate. It is 0.8 meter above the ground, 1 meter below top of vertical part, and 10 meters below where the ledge disappears under the ground. It is S. 70° E., 75 meters from mouth of Le Croix Creek, and 1,574 meters above lower U. S. water-gauge at Gray's Point, Mo., being just in view of the lower part of Cape Girardeau, Mo. The letters U. S. P. B. M. are cut in the face of the rock. Elevation, 110^{m}.9056.

U. S. P. B. M. 58 is center mark on horizontal copper bolt leaded in the vertical face, looking toward the river, of the center one of three large rocks, the lowest and largest of which forms the bank of the river, and is known as "Counterfeit Rock," or "Standing Rock of the Grand Chain." It is 10 meters from the top of the river bank, 80 meters above the line between Matthew Roe and H. S. Wray, 600 meters above Wray's Landing on the land of said Matthew Roe, situated about three miles above Commerce, Mo. It is about 0.8 meters above the ground. The letters U. S. P. B. M. are cut in the rock. Elevation, 110^{m}.6773.

U. S. P. B. M. 59 is the center of a horizontal copper bolt leaded in the steeply inclined face, looking toward the river, of a large silicious rock mostly covered with earth, being one of a group of many in a ravine 1,190 meters above U. S. P. B. M. 60, in Commerce. It is 0.6 meters above the ground, and about 60 meters back from the river, the ground rising in this distance 15 meters. It is in a shallow, rocky ravine, at upper side of the first strip of cultivated land, near the river, south of the bluffs, on land of Mrs. C. Halfner. The letters U. S. P. B. M. are cut in the rock. Elevation, 118^{m}.7540.

U. S. P. B. M. 60 is point in center of horizontal copper bolt leaded in vertical face of ledge, looking toward the river 0.55 metres above the ground and 3.37 metres above the high water of 1858. The top surface of this rock or ledge, which extends across the street, forms the road bed. It is just in front of a point about 30 meters above Wm. Anderson's large brick house on elevated site at the north or upper end of Commerce, Mo. There are a large number of large pieces of rock lying on the bank here that have from time to time rolled down from the same general ledge, but the one selected is so large and extends back in the bank so far that it is reliable. Elevation, 110^{m}.5032.

U. S. P. B. M. 61 is center of horizontal copper bolt set in front or east face of foundation of Wm. Anderson's large brick dwelling-house at the upper end of Commerce, Mo. It is 2 meters north of center of front entrance and 36 centimeters above the ground. Elevation, 116^{m}.6307.

U. S. P. B. M. 62 is mark in center of horizontal copper bolt set in the vertical face of the northwest abutment of stone culvert under road over Muddy Creek, 1 meter above the ground, 75 meters from the top of the river bank and 1,960 meters above Santa Fé Store, which latter is opposite Commerce, Mo., in the State of Illinois. This foundation or masonry rests on the natural rock. The letters U. S. P. B. M. are cut in the rock near the bolt. Elevation, 104^{m}.6078.

U. S. P. B. M. 63 is 185 meters right up the same creek (Muddy Creek) in the left hand ravine going up from the culvert in which is U. S. P. B. M. 62. It is center of copper bolt set in vertical face of a very large rock on part of the ledge just on the right of the creek going up, 1.5 meters above the ground, 1.5 meters below the top of the rock, and 2 meters from the projecting end. Elevation, 108^{m}.7967.

U. S. P. B. M. 64 is top of copper bolt in top of stone in ground 1,260 meters back from river, 1 meter north of fence on north side of road leading east from Goose Island P. O., or Atherton's Landing, about 19 miles above Cairo, Ill. Elevation, 107^{m}.5416.

U. S. P. B M. 65 is top of copper bolt in top of stone in ground in woods about 1,500 meters back from river, and 8¼ miles above Cairo Post-Office, Alexander Co., Illinois. It is 26 meters from graded road (otherwise known as levee), and 93 meters from a school-house for negroes, and 2¼ miles below Spies' Mills. Elevation, 103m.4605.

U. S. P. B. M. 66 is top of copper bolt in stone post in open woods. It is 61 meters east of a point on the I. C. R. R., which point on the railroad is 391 meters north of the "three-mile post" from Cairo, Ill. Elevation, 101m.4777.

DESCRIPTION OF PERMANENT BENCH-MARKS BETWEEN KEOKUK, IOWA, AND GRAFTON, ILL.

U. S. P. B. M. 1 is top of copper bolt leaded vertically into coping of shore side of lower lock of Des Moines Rapids Canal, Keokuk, Iowa. Bench is in recess between stone steps and stone pier of lower hydraulic tower, on south side of pier. Elevation, 156m.5370.

U. S. P. B. M. 2 is copper bolt leaded horizontally in south face of Iowa shore pier of R. R. bridge, Keokuk, Iowa, 8 inches above bench of pier, in the tenth stone from west end. Elevation, 156m.7516.

U. S. P. B. M. 3 is copper bolt leaded horizontally in southwest corner of three-story stone building, owned by Mr. Patterson, facing on Water street, second door from corner of Johnson street, Keokuk, Ia., 8 inches above west door-sill, on inner side of outer wall, 50 feet from corner of Water and Johnson streets. Elevation, 161m.3896.

U. S. P. B. M. 4 is small conical hole in rock at intersection of cross-cut in upper surface of top stone of buttress of Des Moines River bridge. Elevation, 158m.4243.

U. S. P. B. M. 5 is copper bolt leaded horizontally into north wall of brick building, 1½ feet from northeast corner, and three feet from ground. Building is in upper end of Alexandria, Mo., facing river, and 60 feet from bank. The north wall faces slough emptying into river, and 50 meters from it. Building owned by Chas. Bocker; post-office located in building. Elevation, 158m.0087.

U. S. P. B. M. 6 is copper bolt leaded horizontally in upper corner of stone masonry on front side of northeast corner of Baptist Church at Gregory's Landing, Mo. Church is 150 meters north from junction of railroad and wagon road. Elevation, 154m.7690.

U. S. P. B. M. 7 is copper bolt leaded vertically in marking-stone set at root of oak tree, 24 meters west of railroad. Stone is 1.7 meters west of tree in northeast corner of field, 10 meters south of small ravine, 650 meters below bridge No. 14. Tree is 12 inches in diameter. Elevation, 157m.2349.

U. S. P. B. M. 8 is copper bolt leaded horizontally in north wall of Down's Hotel. Canton, Mo. Bolt is in fifth stone from ground, fourth stone from corner of wall made by office door entrance, and in second stone from first window west of office entrance. Hotel is on southwest corner of Lewis and Fifth streets. Elevation, 156m.7856.

U. S. P. B. M. 9 is copper bolt leaded horizontally in east side of back foundation of German Methodist Episcopal Church, corner of Sixth and Washington streets, Canton, Mo. Bolt is in third stone from ground and in second from north corner, and directly under window facing east. Elevation, 156m.5849.

U. S. P. B. M. 10 is copper bolt leaded vertically in top surface of southeast corner of south abutment of railroad bridge No. 35 over Wyaconda Creek. Bolt is 2 feet from south face, 4 feet from east face of abutment, and about 1 mile above La Grange, Mo. Elevation, 153m.6120.

U. S. P. B. M. 11 is copper bolt leaded horizontally in northeast corner stone of Quisenberry & Schneider's tobacco works, situated on southwest corner of Washington street and K and St. L. R. R. at Lagrange, Mo. Bolt is in east face, 15 inches from corner of stone and 2 feet from ground. Elevation, 153m.5792.

U. S. P. B. M. 12 is center of copper bolt leaded horizontally in third course of masonry from bottom and ninth from top of west abutment of Quincy R. R. bridge, West Quincy, Mo. Bolt is in north face 2 inches from east corner. Elevation, 151m.7187.

U. S. P. B. M. 13 is copper bolt leaded vertically in top surface of top stone of northeast corner of north pier forming south face of north abutment of covered railroad bridge over the Fabius River. Bolt is near the center of stone 5 feet below and 8 feet east of rail. Elevation, 151m.9146.

U. S. P. B. M. 14 is top of copper bolt leaded vertically in top surface of stone, forming west end of north pier to railroad bridge over North River. Bolt is 8 inches from north edge of stone, 2 feet from west edge, and 14 inches from base of strut. Elevation, 150m.8065.

U. S. P. B. M. 15 is copper bolt leaded vertically in stone post set in northeast corner of cultivated field, 5 meters from wagon road, 15 meters west of railroad, 20 meters from north one of two elm trees standing alone in wagon road, fence forming line between woods and cultivated ground, 466 meters north of Hilton Station. Elevation, 149m.7508.

U. S. P. B. M. 16 is copper bolt leaded horizontally in face of natural rock at east entrance of tunnel at Missouri end of railroad bridge at Hannibal, Mo. Bolt is in rock facing east and on south side of tunnel, 7 feet south of entrance and about 4 feet above road level. Elevation, 155m.2651.

U. S. P. B. M. 17 is copper bolt leaded vertically in top surface of east stone of north abutment of small railroad bridge 1 mile below Hannibal, Mo., and 50 meters northeast of house of Mr. Johnson. Elevation, 147m.8009.

U. S. P. B. M. 18 is copper bolt leaded vertically in top of top course of masonry at river side of north end of principal abutment of railroad bridge across Lick Creek, 800 meters below depot at Saverton, Mo. Elevation, 147m.3801.

U. S. P. B. M. 19 is marking-stone planted in corner of yard of Catharine Hayes, 6 miles south of Saverton, 1½ miles above Ashburn. Stone is 8 meters southwest of southwest corner of house, and 25 meters from river bank, a little below dam at Gilbert's Island. Elevation, 151m.7497.

U. S. P. B. M. 20 is copper bolt set vertically in top of marking-stone set on line of rail fence 8 meters east of large maple tree on east bank of small creek bed, 3 meters north of bridge over creek. Stone is 7 meters south of wagon road, 17 meters west of railroad, 23 meters south of south corner of house of Mr. Warner, and ½ mile north of Ashburn, Mo. Elevation, 150m.5762.

U. S. P. B. M. 21 is marking-stone planted in east edge of cultivated field about 77 meters from south bank of Salt River, at place where Keokuk and Saint Louis Railroad crosses the river. Stone is set about 15 meters to the west of track, nearly opposite the south end of the trestle on south end of bridge. Elevation, 145m.2055.

U. S. P. B. M. 22 is copper bolt leaded vertically in marking-stone in southwest fence corner of fence running east and west and one south. South fence stops at corner, and begins again 10 meters farther east, on east and west fence. Stone is 20 meters west of railroad and 50 meters above mouth of Salt River. Elevation, 148m.9803.

U. S. P. B. M. 23 is copper bolt leaded horizontally in first layer of stone below brick in northeast face of brick saloon on the northwest corner of Water and Main streets, Louisiana, Mo. Bolt is in second stone north of door in same wall of building. Elevation, 148m.9719.

U. S. P. B. M. 24 is copper bolt set vertically in top surface of top stone forming the northeast corner of the west abutment of railroad bridge over Mississippi River at Louisiana, Mo. Top of bolt is even with the surface of the stone. Elevation, 148m.6907.

U. S. P. B. M. 25 is center of hole in copper bolt in side of natural rock 7 meters south of railroad, 9 meters north of oak tree, 14 inches in diameter, on bank above, 500 meters below railroad bridge across gully, and 6,000 meters below railroad bridge across Mississippi River at Louisiana, Mo. Five notches cut in tree. Elevation, 147m.2828.

U. S. P. B. M. 26 is copper bolt leaded vertically in top of marking-stone set at intersection of two fences on south side of lane and west of railroad. Lane is 5 meters wide. The north fence stops before it reaches as far east as the south fence. A small creek is 3 meters north of the north fence. A row of apple trees is just inside the north fence. Stone is 5½ meters west of railroad and 15 meters west of river; about 60 meters east of old log-house of Peter Yaeger, and about 3 miles above Clarksville, Mo. Elevation, 146m.6472.

U. S. P. B. M. 27 is center of horizontal copper bolt leaded in the natural rock in side of small bluff bank 3½ meters east of railroad track, below wagon road, 12 meters from river bank, 440 meters above vinegar works at Clarksville, Mo., and 120 meters below mouth of Calumet Creek. It is between railroad and house of Philip Bedair. Elevation, 148m.0183.

U. S. P. B. M. 28 is copper bolt leaded horizontally in the southeast corner stone of Carroll House, Clarksville, Mo. Stone is at the head of stairs leading to basement. Bolt is set in south face of stone about 10 inches above the sidewalk. Elevation, 146m.5610.

U. S. P. B. M. 29 is top of copper bolt leaded vertically in top surface of marking-stone set in the ground 5 meters east of the Sny Levee, opposite Clarksville, Mo., about 50 meters east of ferry landing in Calhoun County, Illinois. Stone is 220 meters along the levee below where levee crosses chute. Elevation, 142m.8844.

U. S. P. B. M. 30 is copper bolt leaded vertically in top surface of marking-stone set in the ground on east side of Sny Levee at intersection of plantation road, on south of road, which crosses levee and continues to the river. Levee is 50 meters east of river. A large elm stump 6 feet in diameter and 10 feet tall stands in the road 20 meters west of levee. Stone is opposite Island No. 463, about one-third its length above the lower end, and about 3½ miles below U. S. P. B. M. 29, opposite Clarksville. Elevation, 142m.8681.

U. S. P. B. M. 31 is copper bolt leaded vertically in top of marking-stone set on east side of levee at its base, 4 meters east of the middle of levee, in fence corner inclosing field with woods on north side and levee on west side. It is about 100 meters east of river and 175 meters northwest of house occupied by Mr. Gain and owned by Messrs. Rock and Baker. Elevation, 142m.0102.

U. S. P. B. M. 32 is conical hole in top surface of rock projecting from side of wagon road, about half way up steep hill on north bank of small stream, 10 meters north of middle of stone culvert. Rock is at root of two poplar trees growing about 1 foot apart. Bench is at intersection of cross, 6 inches from west edge and 10 inches from south edge of rock, and about 50 meters east of east shore of Hamburg Bay. Elevation, 148^m.6000.

U. S. P. B. M. 33 is top of copper bolt leaded vertically in top surface of natural rock projecting from east side of wagon road about 240 meters south of house of Mr. Blacksmith, and about 4 miles north of Hamburg, Ill. The bolt is 18 inches from corner, and 10 inches from the two sides of the stone, only one corner of which projects. Elevation, 163^m.0372.

U. S. P. B. M. 34 is copper bolt leaded horizontally in the north face of natural rock forming south side of the first creek south of Hamburg, Calhoun County, Illinois. Bench is about 120 meters east on road from where the road makes a sharp bend from south to east. There are a mill and two houses at the turn of the road. Bench is about 5 meters north of fence around orchard. Bolt is about 1 foot below the top surface of rock, and about 4½ feet above creek bottom, which is of stone. Rock is in layers, the bolt being in top layer. Elevation, 141^m.6910.

U. S. P. B. M. 35 is point 1½ inches from south corner and ½ inch from east side of shore line triangulation stone set by Assistant Engineer John Eisenmann. Stone is 38 meters east of river bank, about 250 meters below Island No. 482, and 3½ meters north west of large elm tree marked with two triangles opposite midway between two houses on Westport Island. Elevation, 139^m.9151.

U. S. P. B. M. 36 is top of copper bolt leaded in the top of marking-stone set about 8 meters from the river bank, on the Illinois shore, a short distance south of a point opposite the head of Islands Nos. 487, 486, and 485, and about 1,190 meters above warehouses at Red's Landing, Calhoun County, Illinois. It is ½ meter south of lower fence of two on land of one Ira Lawson, about opposite the head of the aforesaid islands, and about 50 meters north of the boundary line between the land of the above-named Ira Lawson and the land of one John M. Lewis. Elevation, 139^m.6604.

U. S. P. B. M. 37 is cross about in the middle of triangulation stone set by Assistant Engineer John Eisenmann at the root of a large poplar tree about 10 meters from small house and 5 meters from fence surrounding house. The house is opposite the foot of Sterling Island. Elevation, 139^m.5688.

U. S. P. B. M. 38 is top of marking-stone set by Assistant Engineer John Eisenmann 1½ meters west of foot of sycamore tree blazed and marked with a triangle. Stone is 50 meters east of river bank and 27 meters east of road running to Hogville. It is about 800 meters south from Church's Landing, and about 400 meters north from warehouses at Hogville Landing, Calhoun County, Illinois. Elevation, 138^m.7069.

U. S. P. B. M. 39 is top of copper bolt leaded vertically in top of marking-stone set in the ground ½ meter inside the fence on the west side of the field of J. H. Eildemann, about 100 meters north from upper landing warehouse at Turner's Landing, Calhoun County, Illinois. Elevation 139^m.5747.

U. S. P. B. M. 40 is top of triangulation shore line marking-stone set by Assistant Engineer John Eisenmann about 90 meters back from Illinois bank of Mississippi River, about 600 meters south of foot of Island No. 197, and about 2,900 meters south from the lower Turner's Landing warehouse. Elevation, 138^m.6351.

U. S. P. B. M. 41 is center of copper bolt leaded horizontally in solid sand rock above and back of the road, 74 meters east and below top of a hill at point of bluff at West Point, Calhoun County, Illinois, facing the north. It is about 1 meter above level of road, and is about 150 meters around the point from the warehouse at West Point. Elevation, 141^m.9651.

U. S. P. B. M. 42 is center of copper bolt leaded horizontally in the north face of large bowlder rock, imbedded partly in the ground about 40 meters around east from northwest corner of the bluff rocks below Hastings' Landing, Calhoun Co., Ill., about 225 meters below warehouse on the land of E. B. Brown. It is third large bowlder at foot of hill on the north side of corner west from the top of bank of small branch that empties in the river below the warehouse, and is about 8 meters east from fence that leads about southwest from the east side of warehouse at landing. Elevation. 141^m.0863.

U. S. P. B. M. 43 is center of copper bolt leaded horizontally in the west face of bluff rock about 2½ meters underneath where the upper surface of rocks commence to be exposed at the foot of the hill, about 20 meters around north on west side of hill from southwest projecting corner of the bluffs on the north side of the valley, second one north of Martin's Landing, Calhoun Co., Ill., and first one south of valley where John Zarley lives. Elevation, 138^m.9003.

U. S. P. B. M. 44 is center of horizontal copper bolt set in solid bluff rock facing northwest about 900 meters south of Martin's Landing, and about 1,300 meters north of Miller's Landing, Calhoun Co., Ill. It is about 500 meters below a dwelling-house. The bolt is in the upper stratum of exposed rock. Elevation, 138^m.7755.

U. S. P. B. M. 45 is center of horizontal copper bolt leaded in solid bluff rock at Thomas' Landing, Calhoun Co., Ill. The bolt is between the east end of the coke furnace and the river, and about 40 meters above the trestle-work of the coal mine. Elevation, 137^{m}.0149.

U. S. P. B. M 46 is center of copper bolt leaded horizontally in the west end of solid rock at the southern edge of cultivated field, 20 meters from water's edge at high water, 335 meters west of Frank Herchmeyer's dwelling-house, and one mile below Dixon's Landing, Calhoun Co., Ill. Elevation, 144^{m}.6715.

U. S. P. B. M. 47 is center of copper bolt leaded horizontally in solid bluff rock about 12 meters above water edge, at high water, 350 meters north of Point Landing, 25 meters north of small stone ice-house belonging to Joseph Navar, about 5 meters below top of bluff rock, and about 250 meters northeast of Joseph Navar's dwelling-house, in Calhoun Co., Ill. Elevation, 137^{m}.8355.

DESCRIPTION OF PERMANENT BENCH-MARKS BETWEEN KEOKUK, IOWA, AND FULTON, ILL.

U. S. P. B. M. 1 is top of copper bolt leaded vertically in coping of west wall of sluice-way at south end of middle canal lock, 2 miles above Keokuk, Iowa. Elevation, 158^{m}.9537.

U. S. P. B. M. 2 is top of brass bolt leaded vertically in top of coping of west wall near southwest tower of guard-lock at Nashville, Iowa. Marked U. S. P. B. M. Elevation, 160^{m}.8893.

U. S. P. B. M. 3 is at Montrose, Iowa. It is center of hole in copper bolt leaded horizontally in upper foundation stone of brick store building on south corner of Main and Cedar streets. It is on the east side, 3 feet from north corner. Marked U. S. P. B. M. Elevation, 167^{m}.7492.

U. S. P. B. M. 4 is top of copper bolt leaded vertically in top of west end of south abutment of C., B. & Q. R. R. bridge over Painter Creek, 1 mile south of Viele Station, Iowa. Marked U. S. P. B. M. Elevation, 171^{m}.6681.

U. S. P. B. M. 5 is top of copper bolt leaded vertically in northeast corner stone of middle pier of C., B. & Q. R. R. bridge over Little Devil's Creek, one-half mile south of Viele Station, Iowa. Marked U. S. P. B. M. Elevation, 169^{m}.8603.

U. S. P. B. M. 6 is top of copper bolt leaded vertically in top of stone abutment of C., B. & Q. R. R. bridge over Devil's Creek, one-half mile north of Viele Station, Iowa. Marked U. S. P. B. M. Elevation, 171^{m}.3714.

U. S. P. B. M. 7 is at Fort Madison, Iowa. It is top of copper bolt leaded vertically in water-table of the Central Hotel on Front Street, near the depot. It is near the center of the building on the south side. Marked U. S. P. B. M. Elevation, 168^{m}.9910.

U. S. P. B. M. 8 is at Fort Madison, Iowa. It is center of hole in copper bolt set horizontally in middle of west side of brick chimney of wooden-ware factory on northeast corner of Front and Broadway streets. Bolt is 3 feet above base of chimney. Building owned by W. H. Cretzinger. Marked U. S. P. B. M. Elevation, 170^{m}.5628.

U. S. P. B. M. 9 is on brick house of James Gibbs, 4 miles above Fort Madison, Iowa. It is center of hole in copper bolt leaded horizontally in top foundation stone on south side, 3 feet from southeast corner. House stands about 150 meters west of C., B. & Q. R. R. track. Marked U. S. P. B. M. Elevation, 172^{m}.4908.

U. S. P. B. M. 10 is on east abutment of C., B. & Q. R. R. bridge over Skunk River, 9 miles north of Fort Madison, Iowa. It is top of copper bolt leaded vertically in north end of abutment. Marked U. S. P. B. M. Elevation, 173^{m}.1240.

U. S. P. B. M. 11 is on stone building known as Patterson's grocery, 3¼ miles south of Burlington, Iowa, on south side of C., B. & Q. R. R. It is center of hole in copper bolt set horizontally on north side, near northeast corner, 2¼ feet from the ground. Marked U. S. P. B. M. Elevation, 170^{m}.7091.

U. S. P. B. M. 12 is 2½ miles south of west end of Burlington R. R. bridge, in natural rock, on line of C., B. & Q. R. R. It is 700 meters south of trestle near saw-mill, is 4 meter from centre of track and ¼ meter above track. It is center of hole in copper bolt leaded horizontally in base of limestone bluff near end of cut. Marked U. S. P. B. M. Elevation, 168^{m}.1657.

U. S. P. B. M. 13 is on north end of west abutment of the C., B. & Q. R. R. bridge over Mississippi River at Burlington, Iowa. It is top of copper bolt leaded vertically in abutment. Marked U. S. P. B. M. Elevation, 171^{m}.3968.

U. S. P. B. M. 14 is on north end of east abutment of same bridge. It is top of copper bolt leaded vertically in abutment. Marked U. S. P. B. M. Mackenzie B. M. 49 is on same abutment, and is 6 millimeters above U. S. P. B. M. 14. Elevation, 171^{m}.4352.

U. S. P. B. M. 15 is on east abutment of C., B. & Q. R. R. bridge over Prairie Slough, about 2 miles above the east end of bridge across the Mississippi River at Burlington. It is top of copper bolt leaded vertically in north end of abutment. Marked U. S. P. B. M. Elevation, 167^{m}.6764.

U. S. P. B. M. 16 is on north end of west abutment of trestle No. 59, about 4¼ miles north of the east end of the Burlington bridge, on the line of the C., B. & Q. R. R. It is top of copper bolt leaded vertically in abutment. Marked U. S. P. B. M. Elevation, 168^{m}.1635.

U. S. P. B. M. 17 is on Robt. Moir's brick store building at Oquawka, Ill. It is center of hole in copper bolt leaded horizontally in stone pillar at southwest corner, about 2 feet above the water-table. The building stands on the northwest corner of Schuyler and Second streets, and is also used for the Journal office. Marked U. S. P. B. M. Mackenzie B. M. 48 is on step of same building. Elevation, 169^{m}.5262.

U. S. P. B. M. 18 is on brick building on the southeast corner of Third and Schuyler streets, at Oquawka, Ill. It is center of hole in copper bolt set horizontally on west side of northwest corner, 2½ feet above the ground. Marked U. S. P. B. M. Elevation, 173^{m}.1367.

U. S. P. B. M. 19 is on brick building on the northwest corner of Main and Second streets, Keithsburg, Ill. It is top of copper bolt leaded vertically in stone step on the south side of the building, and marked U. S. P. B. M. The building is owned by Mr. Parsons, and used for a furniture store. Elevation, 170^{m}.6252.

U. S. P. B. M. 20 is on step of Mr. Rife's brick dwelling on the northwest corner of Main and Fifth streets, Keithsburg, Ill. It is top of copper bolt leaded vertically in the southwest corner of upper stone step on south side of house, and is not marked. Elevation, 173^{m}.6488.

U. S. P. B. M. 21 is on foundation of water-tank 2 miles east of New Boston, Ill., in line of C., B. & Q. R. R. It is center of hole in copper bolt set horizontally on west side of tank, under a strut, below top of foundation. It is 150 meters east of covered railroad bridge over Edwards' River. Marked U. S. P. B. M. Elevation, 175^{m}.2622.

U. S. P. B. M. 22 is on foundation of Keokuk Northern Line Packet Company's warehouse at New Boston, Ill. It is center of hole in copper bolt set horizontally in north wall near the northeast corner in top of stone foundation, 0.7 meter from ground. Marked U. S. P. B. M. Elevation, 172^{m}.2639.

U. S. P. B. M. 23 is on Union Hotel, New Boston, Ill. It is center of hole in copper bolt set horizontally in north wall, 0.4 meter from the northeast corner and 1.1 meters from ground. Marked U. S. P. B. M. Elevation, 180^{m}.0117.

U. S. P. B. M. 24 is on top of southeast corner of stone foundation of tall chimney of old saw-mill at Port Louisa, Iowa. Mill now torn down. This is the same bench-mark as Mackenzie B. M. 45. Elevation, 172^{m}.3074.

U. S. P. B. M. 25 is top of stone set in ground 22 meters south of gate leading to Esq. Walton's house, 7½ miles south of Muscatine, Iowa. Stone is a height of high water of 1851, is 8 meters north of wagon road, and 15 meters from edge of river bank. A block is set over the stone, three marking-stakes set 3 feet off, and three small black locust trees blazed near by. Stone is said to have been set by Major Allen several years ago. Top of stone is about 1 foot below the surface of the ground. Elevation, 172^{m}.0010.

U. S. P. B. M. 26 is on brick foundation of Mr. E. Beatty's dwelling on right bank of river, about 7 miles below Muscatine, Iowa. It is center of hole in copper bolt set horizontally in east side of northeast corner of foundation. Marked U. S. P. B. M. Elevation, 173^{m}.2544.

U. S. P. B. M. 27 is on brick chimney of Hershey's lower saw-mill, Muscatine, Iowa. It is center of hole in copper bolt set horizontally on the middle of the east face of chimney, about 3 feet above ground. Marked U. S. P. B. M. Elevation, 173^{m}.8371.

U. S. P. B. M. 28 is on water-works chimney, at Muscatine, Iowa. It is center of hole in copper bolt set horizontally in north face of chimney, about 1.1 meters from the ground. Marked U. S. P. B. M. Elevation, 174^{m}.2968.

U. S. P. B. M. 29 is on north abutment of wagon bridge, 50 meters north of station at Muscatine, Iowa. It is top of copper bolt set vertically in northeast corner of abutment. Marked U. S. P. B. M. Elevation, 174^{m}.4349.

U. S. P. B. M. 30 is on abutment of C., R. I. & P. R. R. bridge, 3 miles north of Muscatine, Iowa. It is top of copper bolt set vertically in top of stone coping of south end of west abutment. Marked U. S. P. B. M. Elevation, 174^{m}.7935.

U. S. P. B. M. 31 is on abutment of C., R. I. & P. R. R. bridge over Sweetland Creek, about 5 miles north of Muscatine, Iowa. It is top of copper bolt leaded vertically in west end of north abutment. Marked U. S. P. B. M. Elevation, 174^{m}.5547.

U. S. P. B. M. 32 is in natural rock on line of C., R. I. and P. R. R., about 6 miles above Muscatine, Iowa. It is center of hole in copper bolt set horizontally in face of rock, where it has been blasted off for railroad bed. It is 4 feet above the track, 20 feet north of center of track, and 740 meters west of bridge 77. Marked U. S. P. B. M. Elevation, 177^{m}.1881.

U. S. P. B. M. 33 is on foundation of pottery owned by John Feasted, at Fairport, Iowa. It is center of hole in copper bolt set horizontally in west side, near southwest corner of stone foundation. This pottery is about 350 meters above railroad station and near the river bank. Marked U. S. P. B. M. Elevation, 175^{m}.3891.

U. S. P. B. M. 34 is on middle pier of bridge over Pine Creek, about 2 miles north of Montpelier, Iowa, on the line of the C., R. I. and P. R. R. It is top of brass bolt leaded vertically in north end of pier. Bridge is No. 60. Marked U. S. P. B. M. Elevation, 176^{m}.0998.

U. S. P. B. M. 35 is on south pier of C., R. I. and P. R. R. bridge No. 52, 1 kilometer south of Montpelier, Iowa. It is top of brass bolt set vertically in west end of pier. Marked U. S. P. B. M. Elevation, 178^{m}.2111.

U. S. P. B. M. 35 *a* is on west abutment of C., R. I. and P. R. R. bridge No. 45, about ¼ mile east of the depot at Montpelier, Iowa. It is top of brass bolt leaded vertically in south end of abutment. Marked U. S. P. B. M. Elevation, 175^{m}.9233.

U. S. P. B. M. 36 is on Wm. Karge's brick store and post-office building at Buffalo, Iowa. It is center of hole in brass bolt leaded horizontally in the east side, near southeast corner, 3 feet above the foundation. The building is on the northwest corner of Hecker and Second streets. It is unmarked. Elevation, 178^{m}.4006.

U. S. P. B. M. 37 is on foundation of brick house of Eliza M. Dodge, ½ mile east of Buffalo, Iowa. It is center of hole in brass bolt set horizontally in upper foundation stone on west side, near southwest corner, about 1 meter from ground. House stands about 100 meters north of line of C., R. I. and P. R. R. Marked U. S. P. B. M. Elevation, 179^{m}.4669.

U. S. P. B. M. 38 is on foundation of vinegar works at lower end of West Davenport, Iowa, near the river bank. It is center of brass bolt set horizontally in west side, near the southwest corner, about 0.4 meters from ground. Marked U. S. P. B. M. Elevation, 179^{m}.0291.

U. S. P. B. M. 39 is on north abutment of Rock Island and Davenport Railroad bridge over the main channel of the Mississippi River. It is top of copper bolt leaded vertically in coping of east or upper side of abutment, on a plane with the sidewalk. It is 4.1 meters from river face of abutment, and 0.1 meter inside of railing. Marked U. S. P. B. M. Elevation, 180^{m}.8749.

U. S. P. B. M. 40 is on base of stone tower of U. S. arsenal stone building, A, 1865, at lower end of Arsenal Island. It is center of hole in copper bolt leaded horizontally in east side of northeast corner, about 4 feet from the ground. Marked U. S. P. B. M. Elevation, 182^{m}.1139.

U. S. P. B. M. 41 is on foundation of the Atlantic Brewery, near C. R. I. and P. R. R. depot at Rock Island, Ill. It is center of hole in copper bolt set horizontally in upper foundation stone on the north side at the northeast corner. Marked U. S. P. B. M. Elevation, 183^{m}.3053.

U. S. P. B. M. 42 is on south abutment of wagon-bridge crossing from Moline, Ill., to head of Rock Island. It is top of copper bolt set vertically on east end of abutment. Marked U. S. P. B. M. Elevation, 179^{m}.5708.

U. S. P. B. M. 43 is on brick basement of H. Smith's dwelling-house at Watertown, Ill. It is center of hole in copper bolt leaded horizontally in the west side near the northwest corner. The house stands 50 meters southeast of the C., M. and St. P. R. R. depot. It is marked U. S. P. B. M. Elevation, 181^{m}.4283.

U. S. P. B. M. 44 is on brick school-house at Hampton, Iowa. It is center of hole in copper bolt set horizontally 0.5 meters from ground on east side near southeast corner of large new public-school building. It is marked U. S. P. B. M. Elevation, 182^{m}.9988.

U. S. P. B. M. 45 is on stone foundation of Baker and Hayward's brick store building on levee at Hampton, Ill. It is center of hole in copper bolt leaded horizontally in north side of northwest corner of building, and is at the H. W. mark of 1880. Marked U. S. P. B. M. Elevation, 179^{m}.9437.

U. S. P. B. M. 46 is on stone foundation of H. M. Gilchrist's brick store building at Rapids City, Ill. It is center of hole in copper bolt leaded horizontally in west side of northwest corner, 4 feet above ground. The building is on the river bank. Marked U. S. P. B. M. Elevation, 181^{m}.8416.

U. S. P. B. M. 47 is on abutment of bridge of C., M. and St. P. R. R. over Barber's Creek, ¼ mile south of Port Byron, Ill. It is top of copper bolt leaded vertically in west end of north abutment. Marked U. S. P. B. M. Elevation, 182^{m}.9513.

U. S. P. B. M. 48 is on foundation of Mr. N. Dorrance's brick store building at Port Byron, Ill. It is center of hole in copper bolt leaded horizontally in west side of southwest corner of stone foundation, and marked U. S. P. B. M. The building stands between Main street and the R. R. track, and about 75 feet from the river bank. Elevation, 183^{m}.4013.

U. S. P. B. M. 49 is on iron doorstep of new brick store building of A. H. Wandt at Port Byron, Ill. It is top of north bolt-head of front row of bolts on south doorstep on east side of building on east side of Main street. Bolt-head marked with a cross cut through its center by a cold-chisel. Marked U. S. P. B. M. on bricks below. Elevation, 185^{m}.2033.

U. S. P. B. M. 50 is on stone warehouse of Northern Line Packet Co., at Cordova, Ill. It is center of hole in copper bolt set horizontally in south side, near southwest corner, and marked U. S. P. B. M. The warehouse stands at water's edge, and the bench is 2 meters below high-water mark. Mackenzie B. M. 39 is on same building. Elevation, 181^{m}.0544.

U. S. P. B. M. 51 is on stone foundation of Wm. G. Marshall's brick elevator, near C., M. and St. P. R. R. depot at Cordova, Ill. It is center of hole in copper bolt set horizontally in north face, near northwest corner, in third corner stone from top of foundation. Marked U. S. P. B. M. Elevation, 187^{m}.5145.

U. S. P. B. M. 52 is on foundation of brick store building of Harper & Son at Albany, Ill. It is center of hole in copper bolt set horizontally in west side at southwest corner of building, and marked U. S. P. B. M. The building is some 90 meters from river, and fronts on the main business street of the town. It is almost directly back of their old brick storehouse, now caving into the river, on which is Mackenzie B. M. 37. Elevation, 187^{m}.6990.

U. S. P. B. M. 53 is on base of a large shoulder of natural rock projecting from the bluff 1¼ miles north of Albany, Ill. It is center of hole in copper bolt leaded horizontally into the base of cliff 1 foot above ground and about 3.5 meters above a wagon-road, and marked U. S. P. B. M. It is 15 meters east of wagon-road and 90 meters east of C., M. and St. P. R. R. Elevation, 188^{m}.6009.

U. S. P. B. M. 54 is on abutment of C., M. and St. P. R. R. bridge, 2¼ miles north of Albany, Ill. It is top of copper bolt set vertically in west side of south abutment. Marked U. S. P. B. M. Elevation, 182^{m}.2995.

U. S. P. B. M. 55 is on south abutment of bridge over Cat Tail Creek of C., M. and St. P. R. R. It is top of copper bolt set vertically in top of east end of abutment. This bridge is just south of the line of the C., B. and Q. R. R., and about 2 miles south of Fulton, Ill. Elevation, 183^{m}.2978.

U. S. P. B. M. 56 is on east end of north abutment of C., M. and St. P. R. R. bridge over Cat Tail Creek, 2 miles south of Fulton, Ill., and about 200 meters south of C., B. and Q. R. R. crossing. It is top of copper bolt set vertically in top of abutment. Elevation, 183^{m}.6809.

C 1.

REPORT OF ASSISTANT ENGINEER L. L. WHEELER, UPON CUMULATIVE ERRORS IN PRECISE LEVELING.

SAINT LOUIS, *October* 6, 1883.

SIR: I have the honor to submit the following report upon the results of investigations of the subject of cumulative errors in leveling.

This investigation was commenced some time since, and an incomplete report made upon the results obtained, with the intention of completing the report when additional data, which was being reduced, should be available. In the meantime, considerable additional field-work has been done, under instructions from yourself to conduct the operations in such a manner as to throw additional light upon the subject. The notes of this work have been reduced, and the results show either that this discussion has had a practical value in avoiding operations which introduced summative errors in the work, or that the observers had attained a proficiency not previously shown.

The preliminary report has been read by those interested in the subject, some corrections have been noted, and some sharp criticisms made. I have, therefore, in writing this report, had the advantage of these facts and the additional data at hand, and have endeavored to show more clearly that the results of leveling operations may be affected by such large cumulative errors as to make them unreliable, and that these cumulative errors may be avoided by proper care in the field-work.

The fact that errors appear in the results of leveling which are nearly constant in sign and amount, has frequently been noticed, and various theories have been advanced to suit the various examples. In this discussion I have endeavored to ascertain some general law to apply to all the data at hand. I have first analyzed the data and arranged it in such a manner as to bring together results obtained under conditions to allow of their being classed together. I have then plotted the results to show more clearly the basis of my assumption of the general law from a study of the curves thus formed. I have then applied the law to the examples obtained from the results of leveling along the Mississippi River, and by the method of least squares obtained values of the unknown quantities which evidently are near the truth. I have even pointed out how, sometimes, from the results of the levels themselves a correction to the final result is shown to be necessary, and the probable value of that correction.

The only absolute control that can be obtained upon the results of levelings is to have the levels return to the starting point, or to level in a polygon. We may, however, consider any line leveled by the same observer in opposite directions to be a polygon, and the error of closing upon the starting point is the sum of all the errors committed in leveling the polygon.

Should it happen that an observer had closed but a single polygon, we would be in doubt whether the error of closure was due to accidental errors or to some general law, unless we had additional evidence in the case. If, however, an observer had leveled a great number of polygons, and the errors of closure showed a preponderance in one direction, both in sign and amount, the existence of some law of the distribution of errors of that observer would be revealed. At the same time it must be remembered that the results are also affected by accidental errors, to which all observations are subject, which in any particular case may be so large as to apparently exempt the observation from the general law. In a series of observations, however, the accidental errors will be nearly counterbalancing, while the existence of a general law will become more evident as the series is extended. It frequently happens, too, in a number of consecutive observations of any kind, that the arrangement of the accidental errors will be such as apparently to point to some law of distribution, but which is disproven on the series of observations being further extended. In this discussion only extended series of observations have been used to base conclusions upon, less extended series having been given only to make some portions of the discussion complete.

In order to more clearly show the presence of cumulative errors in the examples here given, the sums of the errors have been taken at each point in the line and plotted as ordinates, with the distance from the starting point as abscissas.

By this arrangement, however, when a number of consecutive accidental errors have the same sign, the result has been to move the curve to one side of the mean line and allow it to remain there until the effect has been counterbalanced by accidental errors of the opposite sign. This fact will explain the sinusoidal form which some of the curves take. This must be true to a greater or less extent in any series of observations where the errors are continually summed, as has been the case here.

What has been said in regard to a single observer leveling lines in opposite directions, showing the presence of cumulative errors, is also true of different observers leveling the same lines; but, in the latter case, only the relative errors would be shown, unless each closed the polygons. An example is given on page 425 of "*Nivellement de Précision de la Suisse,*" of two observers having leveled the entire perimeter of a polygon of 275 kilometers in opposite directions. The polygon has 4 sides, and is divided by bench-marks of the first order into 40 sections. The discrepancies between the two observers' results on these sections are 30 positive, 8 negative, and 2 equal to zero, and the total discrepancy between the two observers at the end is $+247^{mm}.8$. If there were no additional evidence, the means of the results obtained by the two observers would be accepted as the most probable values, but in this case we have additional evidence. The first observer closed the polygon with $219^{mm}.2$ too great an elevation, and the second with an elevation also too great by $28^{mm}.6$. The mean of the results of the two observers failed to close the polygon by $95^{mm}.3$; or the second observer's result was nearer the truth than the mean of both. It is evident, then, that the discrepancy between the two observers is mainly caused by errors of the first observer, and that whatever system of adjustment may be applied to this polygon, the first observer's results must receive larger corrections than those of the second. It is evident also that the causes of the first observer's errors were in operation during the leveling of nearly the whole polygon.

On Plate I, is given a plot of the discrepancies between the north and south lines leveled by Assistant J. A. Paige between Columbus and Memphis, and between Friar's Point and Prentiss.

The lines, the results of which are there plotted, are not consecutive, but are scattered along throughout the entire distance, which is about 404 kilometers. They are taken, however, in the order in which they occur. The abscissas are twice the sums of the lengths of the lines, or the sums of the perimeters of the polygons, and the ordinates are the sums of the differences between north and south levelings. The dotted line is a mean line put in by inspection, and the broken line is the mean line determined by the least square reduction. The two lines represent different equations. The points plotted in on dash-and-dot line are the actual residuals of the observation equations, and may be said to represent the accidental errors of observation.

On Plate II, is given a plot of the discrepancies between north and south lines leveled by L. L. Wheeler, between Austin and Friar's Point, Miss. The explanation given above applies to this section, except that in this example the lines are consecutive.

On Plate III, is given a plot of discrepancies between north and south lines leveled by Assistant O. W. Ferguson in part of the line from Grafton to Cairo, Ill. The lines are not consecutive, but are taken in the order in which they occur. There were more lines leveled, but the results do not show any accumulation of error, and are not here given. No attempt has been made to put in a mean line, as it is evident that a straight line would not answer the purpose.

It is probable that the change in rate of accumulation of error is due either to changes in methods of observing or to changes in circumstances under which the work was done; and, as these changes could not now be accurately determined, no discussion of this example has been attempted. It may be noticed, however, that the errors increase faster than the distances, while the previously accepted theory has been that they should increase with the square root of the distances. That is, theory would make the curve concave toward the axis of abscissas, while in reality it is convex.

On Plate IV, is given a plot of discrepancies between results of levels by J. A. Paige and B. D. Frost, over lines in the same direction between Columbus and Memphis and Friar's Point and Prentiss. The lines are not consecutive, but are in the order in which they occur.

On Plate V, is given a plot of discrepancies between results of levels by J. B. Johnson and O. W. Ferguson over lines in opposite directions of a portion of the line from Keokuk to Grafton. The lines given are consecutive. The remaining portion of the line shows no accumulation of errors, and is not here given. The point at which the divergence between the two observers commences is $110^{km}.46$ from the starting point, and the divergence continued for 110 kilometers.

Hitherto all attempts to arrive at a value of the precision of levels have been based on the assumption that the errors increase with the square root of the distance leveled. This assumption would be true if accidental errors were the only ones made, and if the number of observations were strictly proportional to the distance leveled. Limitations of discrepancies between results in instructions for precise leveling have been based on the same principle, and are open to the same objection. It has frequently been noticed that while the results of each of a number of lines leveled were well within limits which were prescribed to be in proportion to the square root of the distance, yet when the sum of several lines was considered, the total discrepancy would exceed the limit prescribed. In other words, the errors were not proportional to the square root of the distances and did not follow the law of distribution of accidental errors. Plus and minus errors were not equally prevalent.

This fact is conclusively shown by results given on the plots referred to. Numerous examples of this unequal distribution of errors may be found in published reports of the U. S. Lake Survey, and in the results of levels in Switzerland, Germany, and British India.

An examination of the several plots shows that the results there given are affected by cumulative errors, that these errors vary in sign and amount with different observers, and, with the exception of that on Plate III, *that they are nearly if not quite proportional to the distance leveled.* Theoretically, if the results of levels were affected by a constant error, the effect of that error would be proportional to the number of observations or instrument stations; but these are so nearly proportiona to the distance for any one observer, that the distance has been substituted for the number of observations in this discussion. Since the cumulative errors vary with different observers, they have been called personal errors.

From a study of all the reliable levels at hand, we are led to believe that the error of closing a polygon is made up of two parts: First, a constant error which is proportional to the perimeter, and may be determined with more or less precision from all the polygons leveled; and, second, the sum of the accidental errors to which all observations are subject. Having made this assumption, what follows are but logical conclusions from it, and the proof of the assumption will lie in the results obtained when applied to practical examples.

Now, let $2K$=equal the perimeter of a polygon,
$n-s$=the error of closing the polygon,
x=the personal error of the observer,
and v=the sum of the accidental errors in the polygon.

Then each polygon would give an equation of the form

$$2Kx-(n-s)=v \tag{1}$$

and from all the equations we would obtain the normal equation

$$[4K^2]x-[2K(n-s)]=o. \tag{2}$$

In the same manner, if two observers have leveled the same lines, we may obtain their realative personal equation. If they have leveled the lines in the same direction, we obtain the difference of their personal errors, and, if in opposite directions, the sum of their personal errors.

If we let x' represent the relative personal equation of the two observers, then each line leveled would give an equation of the form

$$Kx'-(n-s)=v \tag{3}$$

in which K equals length of line, and $(n-s)$ discrepancy between results. From all the lines leveled we would obtain the normal equation

$$[K^2]x'-[K(n-s)]=0 \tag{4}$$

Since in equations (2) and (4) there is but one unknown quantity in each case, the coefficients $[4K^2]$ and $[K^2]$ are the weights of the unknown quantities. From this we see that the personal error of a single observer, duplicating his work in opposite directions, can be determined with four times the precision that the relative personal equation of two observers can be obtained from the same lines leveled once by each observer. In the case of a single observer, the sign of the error is determined, and the error eliminated from the mean of results in both directions, while with two observers we are in ignorance as to the sign and amount of the error made by each, and hence, of the error remaining in the mean, unless we have additional evidence. From this we arrive at the practical conclusion that *each observer should duplicate his own work in opposite directions.*

Having obtained the value of x (or x') from equations (2) or (4) and substituted it in the several equations, the several values of v are obtained.

Let r_0 = probable error of a single observation upon the value of x,
$[vv]$ = sum of the squares of the several values of v,
m = number of observations = number lines leveled.

(5) Then,
$$r_0 = \pm\, 0.6745 \sqrt{\frac{[vv]}{m-1}}$$

Having found r_0 we may compute the probable error of the unknown quantity by the formulæ

(6)
$$r_x = \frac{r_0}{\sqrt{p}}, \; p_x \text{ being the weight of } x.$$

The formulæ obtained above relate to either (2) or (4), but what follows relates to (2) alone. Since the several values of v represent the accidental errors of observations, and as these are proportional to the square root of the number of observations, we have, letting n, n_2, n_3, &c., represent the number of observations (instrument stations.)

$$\frac{v_1 v_1}{n_1} = \frac{v_2 v_2}{n_2} = \frac{v_3 v_3}{n_3}, \text{ \&c.}, = \frac{v_m v_m}{n_m}$$

Since, however, in any particular case, the values of n will be very nearly proportional to the distances, we may write

$$\frac{v_1\, v_1}{2\,\mathrm{K}_1} = \frac{v_2\, v_2}{2\,\mathrm{K}_2} = \frac{v_3\, v_3}{2\,\mathrm{K}_3}, \text{\&c.} = \frac{v_m\, v_m}{2\,\mathrm{K}_m}.$$

The expressions $\frac{v_1\, v_1}{2\,\mathrm{K}_1}$, $\frac{v_2\, v_2}{2\,\mathrm{K}_2}$, &c., represent the squares of the errors of closing of polygons whose perimeters equal unity, which is here taken as one kilometer. To find, then, the probable error of closing a polygon whose perimeter equals one kilometer, or what is the same thing, the probable error of a single leveling per kilometer, we have

(7)
$$r = \pm\, 0.6745 \sqrt{\frac{1}{m}\left[\frac{v\,v}{2\mathrm{K}}\right]}$$

r may be taken as a measure of the precision of an observer's work, but in comparing different observers' work it should be remembered that the relation of n to 2K may be quite different for different observers.

One observer may make his observations under such conditions as to necessitate in the mean 12 instrument stations per kilometer, and the other may only make 6 instrument stations in the same distance.

r being the probable error of a single leveling per kilometer, the probable error of the mean of two levelings would be $\frac{r}{\sqrt{2}}$, and the probable error of the difference of elevation of two bench-marks at the ends of a section consisting of m lines whose aggregate length was [K] would be

(8)[*]
$$\mathrm{R} = \frac{r}{\sqrt{2}} \sqrt{[\mathrm{K}]} = \pm\, 0.6745 \sqrt{\frac{[\mathrm{K}]}{2m.}\left[\frac{v\,v}{2\mathrm{K}}\right]}$$

The above formulæ have been applied to the results of the levels along the Mississippi River, which now extend from Biloxi, Miss., on the Gulf of Mexico, to Fulton, Ill., a distance of 2,100 kilometers. The results will be taken up in sections as they were leveled, but it will not be necessary to give full explanations in every case. As it sometimes happens that more than one result is obtained in one or both directions, the uniform rule has been adopted of combining the mean of the results in one direction with the mean of the results in the other. The unit of length is one kilometer, and the unit of vertical measurement is one millimeter. The equations have been so arranged that the values of x have the signs of corrections; when positive the closing elevation is too low, and when minus too high.

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[*] The above formulæ for computing the values of r and R are identical in form with those given in "Präcision-Nevellement der Elbe," but were deduced by the writer before he was aware that the same formulæ had previously been obtained. Their use here, however, is restricted to examples where the leveling has been performed *by the same observer in opposite directions* and the personal error eliminated from the results. It is not believed that the formulæ for computing probable errors are applicable to the results of levels, except that the above conditions are fulfilled. The formulæ for personal error and the method of treating the results in order to arrive at an estimate of the precision of the work is believed to be new.

PRECISE LEVELS FROM AUSTIN TO FRIAR'S POINT, MISS.

This section is 43 kilometers in length, and the results of the leveling are published in the Report of the Chief of Engineers for 1879, page 1944. All lines were leveled in opposite directions an equal number of times by the same observer, and the conditions under which the work was done, aside from changes of weather, may be said to have remained nearly the same throughout. An examination of the table of results shows 19 positive and 9 negative discrepancies, and one equal to zero. The sum of the positive discrepancies exceeds the sum of the negative by $+36^{mm}.3$. The sum of the positive discrepancies is $+47^{mm}.6$, and their mean size $+2^{mm}.50$, and the sum of the negative discrepancies $-11^{mm}.3$ and their mean size $-1^{mm}.26$. It is evident the discrepancies are quite unequally distributed, both with regard to sign and amount.

Treating the results of this section by the method previously explained, we obtain the following values:

$$328.22\,x - 164.05 = 0$$

$$x = +0^{mm}.50 \pm 0^{mm}.083$$

$$[vv] = +138.06$$

$$r_0 = \pm 1^{mm}.50$$

$$r_x = \pm 0^{mm}.083$$

$$r = \pm 0^{mm}.88$$

$$R = \pm 4^{mm}.04$$

To express these results in words, we would say that this observer makes elevations too low, as he advances by $+0^{mm}.050 \pm 0^{mm}.083$ per kilometer, that the probable error of a single leveling was $\pm 0^{mm}.88$ per kilometer, and that the probable error of the difference of elevation between Austin and Friar's Point was $\pm 4^{mm}.04$. The numerical work of obtaining these results is given on page 28.

PRECISE LEVELS FROM COLUMBUS, KY., TO MEMPHIS, TENN., AND FROM FRIAR'S POINT TO PRENTISS, MISS.

These two sections include about 404 kilometers, and were leveled by the same observers, with the same party and outfit, during the same field season, and are here treated as one section.

The manner of doing the work was quite varied; sometimes an observer duplicated his work in opposite directions, sometimes in the same direction, either north or south, and, again, two observers would level the same lines, in the same direction, or in opposite directions. This section, then, furnishes us with examples of all the combinations of observers possible, and is, therefore, a valuable one for this discussion. The field work was done between November 4, 1879, and April 22, 1880. As examples of each combination are scattered along throughout the entire distance, the separate lines have been numbered consecutively from Columbus and Friar's Point, the latter numbers being distinguished by accents.

The following exhibits in tabular form the results of leveling this section:

Observers.	Distance.	Number of discrepancies.			Sum of discrepancies.			Mean size of discrepancies.		Values of x and x'.
		+	—	Total.	+	—	Total.	+	—	
	km.				mm.	mm.	mm.	mm.	mm.	mm.
J. A. Paige	*66.7	39	7	46	+326.9	—20.1	+306.8	+8.38	—2.87	+2.03±0.18
B. D. Frost	*23.4	7	11	18	+37.3	—48.2	—10.9	+5.33	—4.38	—0.53±0.35
E. H. Sankee	*18.4	2	7	9	+4.8	—36.3	—31.5	+2.40	—5.19	—0.81±0.21
Paige—Frost	†215.8	25	95	120	+92.9	—589.7	—496.8	+3.72	—6.21	+2.02±0.16
Paige+Frost	*22.0	11	3	15	+76.5	—11.4	+65.1	+6.95	—3.80	+1.47±0.74
Paige—Sankee	†5.3	1	3	4	+3.0	—29.2	—26.2	+3.00	—8.73	+6.12±1.33
Stevens—Frost	†4.6	0	5	5	0.0	—21.9	—21.9	0.0	—4.38	+4.79±0.71

* Leveled in opposite directions. † Leveled in same directions.

The first observer makes elevations too low as he advances by $+2^{mm}.11 \pm 0^{mm}.18$ per kilometer, and makes elevations lower than the second observer when leveling in the same or opposite directions, and also lower than the third observer when leveling in the same direction. We have so many observations on this point that it cannot be doubted that this observer's results were affected by an error which remained very nearly constant throughout the entire season, and where the error has not been eliminated by his leveling in both directions, that a correction to his results is necessary. The sign of the correction is certain, and we may consider that a close approximation to the amount of the correction has been obtained from the 46 equations of condition obtained from lines leveled in opposite directions. This correction applied to the part between Columbus and Memphis for the lines leveled in one direction by this observer would amount to $+220^{mm}$, and to the part between Friar's Point and Prentiss $+107^{mm}$, or a total correction at Prentiss of $+327^{mm} = 1.07$ feet.

The constant error of this observer must have been independent of direction, for he gets the same results, as compared with the second observer, whichever direction he levels. The condition of the ground and changes of weather evidently have nothing to do with the error, for it lasts throughout the entire season, and the second observer when leveling over the same ground at the same time does not obtain similar results.[*]

The results obtained by this observer the following season between Grafton, Ill., and Cairo, Ill., contained no evidence of such a constant error as here shown. It is evident, then, that a duplication in an opposite direction the second season, of lines leveled in one direction during the first, would not have eliminated the constant error from the mean.

From this we have the practical conclusion that an observer should duplicate his work as soon as possible under, as nearly as practicable, the same conditions. The error of this observer cannot be attributed to a settling of the rod supports, but could be explained by supposing that the rods or instrument raised a small amount generally throughout the season.

The discrepancies of the second observer show that his errors were accidental, which fact is also shown by the probable error of determining his personal error.

The third observer made elevations too high as he advanced, but he did not level enough lines to compensate in any appreciable degree the effect of the first observer's personal error.

The fourth observer did so little work that no conclusion could safely be drawn from the results, but the evidence is all in one direction.

The numerical work of obtaining the results contained in the preceding table is given on pages 150 and 151. No attempt has been made to compute the probable error of the resulting difference of elevation of this section, as it is believed that the formulæ for probable errors are not applicable to a large portion of the work.

PRECISE LEVELS FROM PRENTISS, MISS., TO GREENVILLE, MISS.

This section of 72 kilometers was leveled by Assistant J. B. Johnson, and all lines were leveled in opposite directions. After 44.2 kilometers had been leveled with the rods supported on foot-plates, stakes with nails in their tops were driven and the rods supported on these for the remainder of the distance. This section has been cited as furnishing an example of rods settling when supported on foot-plates and rising when supported on stakes. It has, therefore, been divided into two parts, according to the character of supports, and each part analyzed separately, to ascertain if the manner of supporting the rods has introduced a constant error in the results.

Letting $x_,$ and $x_{,,}$ represent the constant error in the two parts, respectively, then by the formulæ previously given we obtain

$$\begin{array}{lll} & \text{mm.} \quad\ \ \text{mm.} & \quad\ \ \text{mm.} \\ x_, & = -0.62 \pm 0.12 , & r_{0,} = \pm 2.70 \\ x_{,,} & = +0.35 \pm 0.17 , & r_{0,,} = \pm 2.79 \end{array}$$

These results would seem to indicate that the manner of supporting the rods had introduced constant errors in the results, but the proof is not positive. An inspection of the discrepancies and residuals in the first part shows—

	mm.
14 negative discrepancies, whose sum is	−62.2
8 positive discrepancies, whose sum is	+15.4
13 negative residuals, whose sum is	−35.4
9 positive residuals, whose sum is	+27.5

The sum of the discrepancies, without regard to sign, is $77^{mm}.6$, and of the residuals $62^{mm}.9$.

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[*] It might be well to state in this connection that in all the work done on the Mississippi River, the principle of eliminating instrumental errors by equal fore and back sights has been followed, and that therefore the accumulation of errors cannot be attributed to errors of adjustment of instruments.

In the second part there are—

	mm.
5 negative discrepancies, whose sum is	—13.1
10 positive discrepancies, whose sum is	+34.1
7 negative residuals, whose sum is	—23.9
7 positive residuals, whose sum is	+22.7

The sum of the discrepancies, without regard to sign, is $47^{\mathrm{mm}}.2$, and of the residuals, $46^{\mathrm{mm}}.5$. These figures show that the process of solution has merely changed the signs of a few of the errors without materially reducing their mean size. The discrepancies themselves show that the errors have little relation to the distances, and the large probable errors of observation point to the conclusion that the difference between $x_{,}$ and $x_{,,}$ is probably due to an accidental distribution of errors. In fact, if three discrepancies of $-14^{\mathrm{mm}}.2$, $-10^{\mathrm{mm}}.4$, and $+11^{\mathrm{mm}}.8$, found on lines $2^{\mathrm{km}}.6$, $2^{\mathrm{km}}.6$, and $3^{\mathrm{km}}.4$ long respectively, were omitted from the discussion, the values of $x_{,}$ and $x_{,,}$ would become $-0^{\mathrm{mm}}.31$ and $+0^{\mathrm{mm}}.07$, respectively, and their difference would scarcely exceed what would be expected from their probable errors.

The suspicion that these discrepencies are the result of accidental errors is strengthened by the fact that this was the observer's first experience in this work, and also by the fact that all his subsequent work shows occasional errors of approximately 10^{mm}. For the later errors the explanation has been offered that they were caused by mistakes of the rodmen, but as errors of reading the rod of 10^{mm} or 20^{mm} frequently occur and are detected in the field or in the reduction, it is quite likely that this is the way that these errors were made and escaped detection.

Numerous examples could be drawn from the note-books of this office where the readings of the three wires are inconsistent, and show that an error of 10^{mm} has been made in reading either one or two wires, with no evidence to decide which is the case. An uncertainty of 10^{mm}, therefore, remains in the mean of the three readings. This explanation of the way errors of that size are made is not confined to this section or to this observer.

We conclude, then, that the proof that changing the manner of supporting the rods had affected the results is not sufficient. That the cumulative error was not the effect of motion of rod supports, would have been inferred from the results of the levels between Columbus and Memphis, where two observers with rods supported alike obtained so dissimilar results while leveling the same lines at the same time. In order to explain the results obtained by the first observer there by a motion of the rod supports, it would be necessary to suppose that a foot plate and rod weighing in all 27 pounds, had *risen* nearly uniformly throughout an entire season. As the pressure on the foot plate would probably be increased by the rodman about 20 pounds, this supposition is inadmissible.

We have, therefore, combined all the results in this section, and obtained the following values:

$$769.52\,x+205.87=0, \quad x=-0^{\mathrm{mm}}.26\pm0^{\mathrm{mm}}.11, \quad [vv]=744.94$$

$$r_o=\pm3^{\mathrm{mm}}.07, \quad r_x=\pm0^{\mathrm{mm}}.11, \quad r=\pm1^{\mathrm{mm}}.48, \quad R=\pm8^{\mathrm{mm}}.68.$$

PRECISE LEVELS FROM GRAFTON, ILL., TO CAIRO, ILL.

The only results obtained in this section of 345 kilometers bearing upon the subject of this discussion were those obtained by Assistant O. W. Ferguson in the 221 kilometers south from Grafton. These results are shown on the plot on Plate III, and reference to them has previously been made. This observer made elevations too low as he advanced, but the error did not remain constant, and the method here given has not been applied to the results. As, during the time that he leveled the lines shown on the plot, he also leveled many lines to the south without duplicating them in the opposite direction, it is probable the difference of elevation obtained between Grafton and Cairo is affected by this cumulative error.

PRECISE LEVELS FROM KEOKUK, IOWA, TO GRAFTON, ILL.

This section of 242 kilometers was leveled in duplicate by two observers, Assistant J. B. Johnson always leveling toward the south and Assistant O. W. Ferguson always leveling toward the north. The work progressed from north to south. Commencing at 110 kilometers at Keokuk and continuing for 110 kilometers, the results of the second observer are lower than those of the first observer. Of the 66 lines included in this portion, 48 gave positive discrepancies, whose sum is $+118^{\mathrm{mm}}.1$, and 18 gave negative discrepancies, whose sum is $-27^{\mathrm{mm}}.0$, and the total discrepancies between the two observers is $+91^{\mathrm{mm}}.1$.

As the plot of the discrepancies on Plate V, shows that this error was practically constant throughout, its value has been found by the formulæ.

$$x = -0^{mm}.62 \pm 0^{mm}.11$$
$$r_0 = \pm 1^{mm}.61$$
$$r_x = \pm 0^{mm}.11$$

As it is more probable that this error was made by one observer than that the two observers made equal errors of opposite signs, the difference of elevation between Keokuk and Grafton is probably in error by 45^{mm} from this cause. The sign of the error is not determined. The numerical work of obtaining these results is given on page 157.

PRECISE LEVELS FROM CARROLLTON, LA., TO BILOXI, MISS.

The levels of this section of 140 kilometers were run by the same observers and in the same manner as those between Keokuk and Grafton. After about 60 kilometers had been leveled, the results of the two observers commenced to diverge until at the end of the line their results differed by about 50^{mm}. The same remarks are applicable to this section as the preceding one.

PRECISE LEVELS FROM CAIRO, ILL., TO COLUMBUS, KY., AND FROM MEMPHIS, TENN., TO AUSTIN, MISS.

The leveling of these sections, with the exception of about 6 miles, was all done in one direction, the observer carrying along two lines by means of two rods, used independently. There is, therefore, no information as to whether or not there was any accumulation of errors in these sections.

PRECISE LEVELS FROM GREENVILLE, MISS., TO CARROLLTON, LA.

The levels of this section of 470 kilometers were run by parties of the United States Coast and Geodetic Survey, and the method pursued was to level alternate sections in opposite directions, in order "to prevent the gradual accumulation of error, supposed to be due to running constantly in one direction" (C. S. Report, 1880, page 137). It is probable that this method prevented any accumulation of error, but it fails to give any evidence on the subject.

The following are the values of r and R, computed by the method given in "Präcision-Nivellement der Elbe," which method is in use by the United States Coast and Geodetic Survey:

$$r = \pm 0^{mm}.90$$
$$R = \pm 11^{mm}.6$$

PRECISE LEVELS FROM KEOKUK, IOWA, TO FULTON, ILL.

The results of all the sections previously mentioned were known before this section was leveled, although the final reductions were not quite completed.

The conclusions to be drawn from them had been pointed out in the preliminary report, and some experimental work had been done with reference to obtaining additional information upon the subject, but the results indicated that the work was not of a character to make it valuable in this discussion.

When the parties took the field they received instructions that each observer should duplicate his own work in opposite directions. In order to throw additional light on the question whether or not the accumulation of errors noticed in some of the sections was caused by a motion of the rod supports, the parties were provided with steel pins, to be used as they saw fit in supporting the rods.

A slight modification was also made in the form of the spur in which the rod terminates. This modification consisted in having the rod terminate in a plane surface, which rested on a conical surface on the foot-plates or pins, instead of terminating in a spherical surface, which rested on a concave spherical surface of larger diameter. The observers were the same as those employed in the sections Carrollton to Biloxi and Keokuk to Grafton.

On pages 158 and 159 is given a tabulation of the results obtained in this section. As the observers leveled alternate portions of the line, the numbering of the bench-marks, which is consecutive, will indicate the order in which the results occur in the line. Sometimes an observer obtained two results at the same time by using both foot-plates and pins. In the tabulation such results are indicated by an asterisk in the column of bench-marks. An examination of the table shows that the discrepancies of either observer are well distributed, both with regard to sign and amount, throughout the season's work, whether leveling on pins or foot-plates; and that the work upon the foot-plates is slightly better than that upon pins. These facts are shown by the following table of discrepancies:

	O. W. F., OBSERVER.				J. B. J., OBSERVER.			
	Pins.		Foot plates.		Pins.		Foot plates.	
	Discrepancies.				Discrepancies.			
	No.	Sum.	No.	Sum.	No.	Sum.	No.	Sum.
		mm.		*mm.*		*mm.*		*mm.*
Positive	41	+83.2	23	+35.8	31	+60.9	32	+71.0
Negative	34	−63.8	23	−51.1	29	−76.2	32	−56.5
Sum	75	+19.4	46	−15.3	60	−15.3	64	+14.5
Mean size	......	1.96	......	1.89	......	2.28	......	1.99

The total discrepancy in all the first observer's work is +4.1^{mm} and in the second −0.8^{mm}, or in the whole section +3.3^{mm}.

This remarkable counterbalancing of errors may partly be accidental, but is probably largely to be attributed to increased care in the work. There is nothing in the results that shows that an accumulation of error was prevented by changing from one kind of support to the other.

The preceding sections include all the levels along the Mississippi River, except those from Fulton to connect with Lake Michigan, at Chicago, which are not yet finally reduced. It is believed that the following conclusions can safely be drawn from the results set forth in the preceding pages.

(1.) The results of leveling may be effected by cumulative errors, which vary with different observers, and do not always remain constant with the same observer.

(2.) The mean of several results obtained by the same or different observers may require a considerable correction.

(3.) That these cumulative errors are nearly proportional to the distances leveled, and in some cases are independent of the nature of the ground, the direction in which the work is done, the season, or the manner of supporting the rods.

(4.) That in order, as far as possible, to eliminate the effect of such errors, each observer should duplicate his own work in opposite directions, under the same conditions.

(5.) That long lines of levels, even if leveled in duplicate, should be independently checked.

The above report is submitted in hopes that it may add information in regard to leveling, and increase the accuracy of future operations. It is hoped that it may meet with your approval.

Very respectfully, your obedient servant,

L. L. WHEELER.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

Determination of personal error of Assistant L. L. Wheeler from the results of levels from Austin to Friar's Point, Miss.

	$2Kx-(n-s)=v$		$4K^2x-2K(n-s)$		v	vv	$\frac{vv}{2K}$
	km.	*mm.*			*mm.*		
(1)	3.1	+ 2.8	+ 9.61	+ 8.68	− 1.2	1.44	0.47
(2)	2.4	+ 0.1	+ 5.76	+ 0.24	+ 1.1	1.21	0.50
(3)	1.7	+ 2.9	+ 2.89	+ 4.93	− 2.1	4.41	2.60
(4)	2.0	− 0.7	+ 4.00	− 1.40	+ 1.7	2.89	1.44
(5)	2.6	+ 4.2	+ 6.76	+ 10.92	− 2.9	8.41	3.23
(6)	2.1	+ 1.2	+ 4.41	+ 2.52	− 0.2	0.04	0.02
(7)	2.1	− 1.1	+ 4.41	− 2.31	+ 2.1	4.41	2.10
(8)	1.5	0.0	+ 2.25	0.00	+ 0.8	0.64	0.04
(9)	4.2	+ 3.2	+ 17.64	+ 13.44	− 1.1	1.21	0.30
(10)	3.4	+ 0.2	+ 11.56	+ 0.68	+ 1.5	2.25	0.66
(11)	2.3	+ 0.8	+ 5.29	+ 1.84	+ 0.4	0.16	0.08
(12)	4.0	+ 3.5	+ 16.00	+ 14.00	− 1.5	2.25	0.56
(13)	1.8	− 0.3	+ 3.24	− 0.54	+ 1.2	1.44	0.90
(14)	6.4	+ 0.8	+ 40.96	+ 5.12	+ 2.4	5.76	0.90

Determination of personal error of Assistant L. L. Wheeler, &c.—Continued.

	$2Kx - (n-s) = v$		$4K^2x - 2K(n-s)$		v	vv	$\frac{vv}{2K}$
	km.	*mm.*			*mm.*		
(15)	2.5	− 0.8	+ 6.25	− 2.00	− 2.0	4.00	1.60
(16)	4.3	+ 4.0	+ 18.49	+ 17.20	− 1.8	3.24	0.75
(17)	1.2	− 3.8	+ 1.44	− 3.36	+ 4.4	19.36	16.13
(18)	3.2	− 1.5	+ 10.24	− 4.80	+ 3.1	9.61	3.00
(19)	5.0	+ 3.5	+ 25.00	+ 17.50	− 1.0	1.00	0.20
(20)	2.7	+ 2.2	+ 7.29	+ 5.94	− 0.8	0.64	0.24
(21)	4.0	− 2.7	+ 16.00	− 10.80	+ 4.7	22.09	5.52
(22)	1.7	+ 0.9	+ 2.89	+ 1.53	− 0.1	0.01	0.01
(23)	4.9	+ 3.8	+ 24.01	+ 18.62	− 1.4	1.96	0.40
(24)	4.0	− 0.2	+ 16.00	− 0.80	+ 2.2	4.84	1.21
(25)	1.0	+ 0.6	+ 1.00	+ 0.60	− 0.1	0.01	0.01
(26)	6.0	+ 8.7	+ 36.00	+ 52.20	− 5.7	32.49	5.41
(27)	4.7	+ 1.7	+ 22.09	+ 7.99	+ 0.7	0.49	0.10
(28)	2.5	+ 2.5	+ 6.25	+ 6.25	− 1.2	1.44	0.58
(29)	0.7	− 0.2	+ 0.49	− 0.14	+ 0.6	0.36	0.51
			328.22	+164.05	[*vv*] =	138.06	49.47

Normal equation:

$$328.22x - 164.05 = 0 \qquad x = +0.50^{\mathrm{mm}} \pm 0.083$$

$$m = 29 \qquad \mu = 1 \qquad p = 328$$

$$r_x = \frac{.6745\sqrt{[vv]}}{\sqrt{p\,(m-\mu)}} = \pm 0.083^{\mathrm{mm}}$$

$$R = \pm 0.6745\sqrt{\frac{43}{29} \times \frac{49.47}{2}} = \pm 4.04^{\mathrm{mm}} \qquad r = \pm 0.88^{\mathrm{mm}}$$

Determination of personal error of Assistant J. A. Paige, from the results of levels from Columbus to Memphis and from Friar's Point to Prentiss.

No. of line.	$2Kx$	$-(n-s)$	v	vv	$4K^2$	$-2K(n-s)$
3	0.8	+ 5.4	= + 7.0	49.00	0.64	+ 4.32
4	2.1	+ 1.4	= + 5.7	32.49	4.41	+ 2.94
9	1.4	− 4.4	= − 1.6	2.56	1.96	− 6.16
12	1.8	− 10.3	= − 6.6	43.56	3.24	− 18.54
13	0.9	+ 0.7	= + 2.5	6.25	0.81	+ 0.63
14	2.3	− 4.1	= + 0.6	0.36	5.29	− 9.43
15	6.3	− 14.3	= − 1.5	2.25	39.69	− 90.09
16	1.7	− 15.0	= − 11.6	134.56	2.89	− 25.50
17	0.8	+ 3.2	− + 4.8	23.04	0.64	+ 2.56
19	4.4	− 21.5	= − 12.6	158.76	19.36	− 94.60
20	8.9	− 12.3	= + 5.8	33.64	79.21	− 109.47
21	2.2	− 4.3	= + 0.2	0.04	4.84	− 9.46
22	6.1	− 5.2	= + 7.2	51.84	37.21	− 31.72
23	3.0	− 6.6	= − 0.5	0.25	9.00	− 19.80
24	2.1	− 8.7	= − 4.4	19.36	4.41	− 18.27
25	3.5	− 6.8	= + 0.3	0.09	12.25	− 23.80
28	1.3	− 1.9	= + 0.7	0.49	1.69	− 2.47
29	2.2	− 17.8	= − 13.3	176.89	4.84	− 39.16
30	4.0	− 24.5	= − 16.4	268.96	16.00	− 98.00
31	5.9	− 14.5	= − 2.5	6.25	34.81	− 85.55
32	0.6	− 1.9	= − 0.7	0.49	0.36	− 1.14
35	3.7	− 3.3	= + 4.2	17.64	13.69	− 12.21
41	1.4	− 3.8	= − 1.0	1.00	1.96	− 5.32
43	2.5	− 4.3	= + 0.8	0.64	6.25	− 10.75
44	4.5	− 5.6	= + 3.5	12.25	20.25	− 25.20
50	1.3	− 0.4	= + 2.2	4.84	1.69	− 0.52
51	5.2	+ 3.1	= + 13.6	184.96	27.04	+ 16.12
66	7.9	− 8.0	= + 8.0	64.00	62.41	− 63.20
68	1.9	− 4.7	= − 0.8	0.64	3.61	− 8.93
82	2.1	− 3.4	= + 0.9	0.81	4.41	− 7.14
83	2.3	− 5.1	= − 0.4	0.16	5.29	− 11.73

Determination of personal error of Assistant J. A. Paige, &c.—Continued.

No. of line.	$2Kx$	$-(n-s)$	v	vv	$4K^2$	$-2K(n-s)$
84	1.9	— 2.4 =	+ 1.4	1.96	3.61	— 4.56
85	1.3	— 7.5 =	— 4.9	24.01	1.69	— 9.75
86	5.8	— 7.8 =	+ 4.0	16.00	33.64	— 45.24
94	1.4	— 9.7 =	— 6.9	47.61	1.96	— 13.58
95	3.9	— 19.0 =	— 11.1	123.21	15.21	— 74.10
96	3.4	— 6.6 =	+ 0.3	0.09	11.56	— 22.44
99	2.7	— 14.8 =	— 9.3	86.49	7.29	— 39.96
101	2.6	— 12.4 =	— 7.1	50.41	6.76	— 32.24
130	0.7	+ 0.4 =	+ 1.8	3.24	0.49	+ 0.28
10′	3.5	— 8.1 =	— 1.0	1.00	12.25	— 28.35
11′	2.3	+ 5.9 =	+ 10.6	112.36	5.29	+ 13.57
18′	1.7	— 5.9 =	— 2.4	5.76	2.89	— 10.03
23′	3.1	— 11.2 =	— 4.9	24.01	9.61	— 34.72
27′	2.0	— 2.1 =	+ 1.9	3.61	4.00	— 4.20
36′	2.0	— 5.7 =	— 1.6	2.56	4.00	— 11.40
				1800.39	550.40	—1118.31

Normal equation:

$$550.40\,x - 1118.31 = 0. \qquad x = +\,2.03^{\mathrm{mm}}$$

To compute prob. error of x:

$$\text{P. E. of } x = 0.6745\sqrt{\frac{[vv]}{p(m-\mu)}} = 0.6745\sqrt{\frac{1800.39}{550.40\times 45}} = \pm\,0.18^{\mathrm{mm}}$$

$$x = +\,2.03^{\mathrm{mm}} \pm 0.18^{\mathrm{mm}}$$

Prob. error of a single observation:

$$r_{o} = \pm\,0.6745\sqrt{\frac{1800.39}{45}} = \pm\,4.27^{\mathrm{mm}}$$

Determinations of personal error of Assistant B. D. Frost from results of levels from Columbus to Memphis and from Friar's Point to Prentiss.

No. of line.	$2Kx$	$-(n-s)=$	v	vv	$4K^2$	$-2K(n-s)$
46	2.8x	— 11.7 =	—13.2	174.24	+ 7.84	—32.76
47	4.8	+ 11.0 =	+ 8.5	72.25	+ 23.04	+52.80
49	1.9	— 0.2 =	— 1.2	1.44	+ 3.61	— 0.38
52	3.1	— 3.6 =	— 5.2	27.04	+ 9.61	—11.16
55	2.3	+ 2.1 =	+ 0.9	0.81	+ 5.29	+ 4.83
57	1.7	+ 1.9 =	+ 1.0	1.00	+ 2.89	+ 3.23
63	4.8	+ 11.0 =	+ 8.5	72.25	+ 23.04	+52.80
87	2.7	+ 5.9 =	+ 4.5	20.25	+ 7.29	+15.93
112	4.3	+ 2.0 =	— 0.3	0.09	+ 18.49	+ 8.60
113	2.9	— 3.0 =	— 4.5	20.25	+ 8.41	— 8.70
114	2.1	+ 5.9 =	+ 4.8	23.04	+ 4.41	+12.39
115	2.2	— 2.5 =	— 3.7	13.69	+ 4.84	— 5.50
141	2.4	+ 0.1 =	— 1.2	1.44	+ 5.76	+ 0.24
142	2.0	+ 4.9 =	+ 3.8	14.44	+ 4.00	+ 9.80
144	1.3	+ 1.9 =	+ 1.2	1.44	+ 1.69	+ 2.47
145	1.5	+ 1.5 =	+ 0.7	0.49	+ 2.25	+ 2.25
147	2.0	— 11.7 =	—12.8	163.84	+ 4.00	—23.40
43′	2.0	— 4.6 =	— 5.7	32.49	+ 4.00	— 9.20
				640.49	+140.46	+74.24

Normal equation:

$$140.46x + 74.24 = 0 \qquad x = -\,0.53^{\mathrm{mm}}$$

Prob. error of a single observation:

$$r_0 = \pm 0.6745\sqrt{\frac{640.49}{17}} = \pm 4.14^{\mathrm{mm}}$$

Prob. error of x:

$$r_x = \pm\frac{r_0}{\sqrt{p_x}} = \pm\frac{4.14}{\sqrt{140.46}} = \pm 0.349^{\mathrm{mm}} \qquad x = -\,0.53^{\mathrm{mm}} \pm 0.349^{\mathrm{mm}}$$

Determination of personal error of Mr. E. H. Sankee.

No. of line.	$2Kx$	$-(n-s)=$	v	vv	$4K^2$	$-2K(n-s)$
13′	$1.6x$	+ 6.3 =	+5.0	25.00	+ 2.56	+ 10.08
14′	5.0	+ 1.6 =	—2.4	5.76	+ 25.00	+ 8.00
15′	4.8	+ 3.2 =	—0.7	0.49	+ 23.04	+ 15.36
16′	4.6	+ 6.7 =	+3.0	9.00	+ 21.16	+ 30.82
17′	4.3	+ 6.0 =	+2.5	6.25	+ 18.49	+ 25.80
19′	4.2	+ 7.9 =	+4.5	20.25	+ 17.64	+ 33.18
28′	4.0	— 1.2 =	—4.4	19.36	+ 16.00	— 4.80
29′	3.2	— 3.6 =	—6.2	38.44	+ 10.24	— 11.52
30′	5.2	+ 4.6 =	+0.4	0.16	+ 27.04	+ 23.92
				124.71	+161.17	+130.84

Normal equation:

$$161.17x+130.84=0 \qquad x=-0.812^{mm}$$

Prob. error of a single observation:

$$r_0=\pm 0.6745\sqrt{\frac{124.71}{8}}=\pm 2.66^{mm}$$

Prob. error of x:

$$r_x=\frac{r_0}{\sqrt{p_x}}=\frac{2.66}{\sqrt{161.17}}=\pm 0.210^{mm} \qquad x=-0.812^{mm}\pm 0.210^{mm}$$

Determination of sum of personal errors of Assistants Paige and Frost, from results of levels between Columbus and Memphis, and Friar's Point and Prentiss.

No. of line.	Kx'	$-(P-F)=$	v	vv	K^2	$-K(P.-F.)$
41	$0.7x'$	— 6.2 =	— 5.2	27.04	0.49	— 4.34
43	1.3	— 3.6 =	— 1.7	2.89	1.69	— 4.68
49	0.9	+ 1.0 =	+ 2.3	5.29	0.81	+ 0.90
52	1.6	—11.2 =	— 8.9	79.21	2.56	—17.92
55	1.2	— 5.5 =	— 3.7	13.69	1.44	— 6.60
57	0.8	— 5.6 =	— 4.4	19.36	0.64	— 4.48
64	2.2	— 9.9 =	— 6.7	44.89	4.84	—21.78
66	3.9	+ 9.6 =	+15.3	234.09	15.21	+37.44
99	1.4	— 9.3 =	— 7.2	51.84	1.96	—13.02
101	1.3	— 2.0 =	— 0.1	0.01	1.69	— 2.60
116	2.3	— 4.0 =	— 0.6	0.36	5.29	— 9.20
130	0.4	— 3.0 =	— 2.4	5.76	0.16	— 1.20
147	1.0	—16.2 =	—14.7	216.09	1.00	—16.20
36′	1.0	+ 0.8 =	+ 2.3	5.29	1.00	+ 0.80
61′	2.0	0.0 =	+ 2.9	8.41	4.00	0.00
				714.22	42.78	—62.88

Normal equation:

$$42.78x'-62.88=0 \qquad x'=+1.47^{mm}$$

Prob. error of a single observation:

$$r_0=\pm 0.6745\sqrt{\frac{714.22}{14}}=\pm 4.82^{mm}$$

Probable error of x':

$$r_x'=\frac{r_0}{\sqrt{p_x'}}=\frac{\pm 4.82}{\sqrt{42.78}}=\pm 0\ \ 4^{mm} \qquad x'=+1.47^{mm}\pm 0.74^{mm}$$

Determination of difference of personal errors of Messrs. Frost and Stevens.

No. of line.	Kx′	— (F — S)	= v	vv	K²	— K (F — S)
140	0.7	— 0.4	= + 2.9	8.41	0.49	— 0.28
141	1.2	— 5.9	= — 0.2	0.04	1.44	— 7.08
142	1.0	— 7.2	= — 2.7	7.29	1.00	— 7.20
143	1.1	— 3.9	= + 1.4	1.96	1.21	— 4.29
144	0.6	— 4.5	= — 1.6	2.56	0.36	— 2.70
				20.26	4.50	—21.55

Normal equation:

$$4.50x' - 21.55 = 0 \qquad x' = +4.79^{\mathrm{mm}}$$

$$r_0 = \pm 0.6745\sqrt{\frac{20.26}{4}} = \pm 1.51^{\mathrm{mm}} \qquad r_x' = \frac{r_0}{\sqrt{p_x'}} = \pm \frac{1.51}{\sqrt{4.50}} = \pm 0.71^{\mathrm{mm}}$$

Determination of difference of personal errors of Assistants Paige and Frost from the results of levels from Columbus to Memphis and from Friar's Point to Prentiss.

No. of line.	Kx′	— (P — F)	= v	vv	K²	— K (P — F)
26	2.0x′	+ 5.9	= + 1.9	3.61	4.00	+ 11.80
27	2.4	+ 16.3	= + 11.5	132.25	5.76	+ 39.12
33	2.0	+ 8.2	= + 4.2	17.64	4.00	+ 16.40
34	1.6	— 2.0	= — 5.2	27.04	2.56	— 3.20
37	2.4	+ 12.3	= + 7.5	56.25	5.76	+ 29.52
38	3.0	+ 15.1	= + 9.0	81.00	9.00	+ 45.30
39	4.6	+ 6.6	= — 2.7	7.29	21.16	+ 30.36
40	3.4	+ 3.7	= — 3.2	10.24	11.56	+ 12.58
41	0.7	— 2.4	= — 3.8	14.44	0.49	— 1.68
42	4.0	— 9.1	= — 17.2	295.84	16.00	— 36.40
43	1.3	+ 0.7	= — 1.9	3.61	1.69	+ 0.91
45	2.3	— 5.4	= — 10.0	100.00	5.29	— 12.42
48	3.9	+ 8.1	= + 0.2	0.04	15.21	+ 31.59
49	0.9	— 1.2	= — 3.0	9.00	0.81	— 1.08
52	1.6	+ 7.6	= + 4.4	19.36	2.56	+ 12.16
53	1.0	+ 2.5	= + 0.5	0.25	1.00	+ 2.50
54	1.5	+ 10.3	= + 7.3	53.29	2.25	+ 15.45
55	1.2	+ 7.6	= + 5.2	27.04	1.44	+ 9.12
56	1.3	+ 4.0	= + 1.4	1.96	1.69	+ 5.20
57	0.8	+ 7.5	= + 5.9	34.81	0.64	+ 6.00
59	1.5	— 1.3	= — 4.3	18.49	2.25	— 1.95
60	2.0	+ 4.1	= + 0.1	0.01	4.00	+ 8.20
61	0.5	+ 0.1	= — 0.9	0.81	0.25	+ 0.05
62	2.4	+ 8.4	= + 3.6	12.96	5.76	+ 20.16
65	0.5	— 3.8	= — 4.8	23.04	0.25	— 1.90
66	3.9	+ 17.6	= + 9.7	94.09	15.21	+ 68.64
67	1.4	+ 9.6	= + 6.8	46.24	1.96	+ 13.44
69	2.3	— 7.5	= — 12.2	148.84	5.29	— 17.25
70	3.8	+ 12.4	= + 4.7	22.09	14.44	+ 47.12
71	1.0	+ 8.0	= + 6.0	36.00	1.00	+ 8.00
72	0.2	+ 1.8	= + 1.4	1.96	0.04	+ 0.36
73	4.3	+ 4.6	= — 4.1	16.81	18.49	+ 19.78
74	0.5	+ 5.1	= + 4.1	16.81	0.25	+ 2.55
75	1.6	+ 10.2	= + 7.0	49.00	2.56	+ 16.32
97	2.9	— 4.9	= — 10.8	116.64	8.41	— 14.21
98	2.2	+ 1.4	= — 3.0	9.00	4.84	+ 3.08
99	1.4	+ 5.5	= + 2.7	7.29	1.96	+ 7.70
100	2.2	+ 3.4	= — 1.0	1.00	4.84	+ 7.48
101	1.3	+ 10.4	= + 7.8	60.84	1.69	+ 13.52
102	0.9	+ 5.2	= + 3.4	11.56	0.81	+ 4.68
103	1.1	+ 2.3	= + 0.1	0.01	1.21	+ 2.53
104	1.5	+ 0.4	= — 2.6	6.76	2.25	+ 0.60
105	1.3	+ 6.1	= + 3.5	12.25	1.69	+ 7.93
106	1.6	+ 5.4	= + 2.2	4.84	2.56	+ 8.64
107	1.7	+ 10.7	= + 7.3	53.29	2.89	+ 18.19
108	1.6	— 2.2	= — 5.4	29.16	2.56	— 3.52
109	1.0	+ 7.0	= + 5.0	25.00	1.00	+ 7.00

Determination of difference of personal errors of Assistants Paige and Frost, &c.—Continued.

No. of line.	$Kx' - (P - F) =$	v	vv	$K^2 - K(P - F)$
110	1.0 + 9.0 =	+ 7.0	49.00	1.00 + 9.00
117	1.9 − 4.5 =	− 8.3	68.89	3.61 − 8.55
118	0.9 + 8.6 =	+ 6.8	46.24	0.81 + 7.74
119	0.5 + 9.1 =	+ 8.1	65.61	0.25 + 4.55
120	1.4 + 5.7 =	+ 2.9	8.41	1.96 + 7.98
121	2.8 + 2.7 =	− 3.0	9 00	7.84 + 7.56
122	0.9 + 8.3 =	+ 6.5	42.25	0.81 + 7.47
123	2.2 + 5.3 =	+ 0.9	0.81	4.84 + 11.66
124	1.2 + 10.2 =	+ 7.8	60.84	1.44 + 12.24
125	1.3 − 1.3 =	− 3.9	15.21	1.69 − 1.69
126	1.2 + 4.7 =	+ 2.3	5.29	1.44 + 5.64
127	1.0 + 2.3 =	+ 0.3	0.09	1.00 + 2.30
128	1.2 + 1.5 =	− 0.9	0.81	1.44 + 1.80
129	2.3 − 4.2 =	− 8.8	77.44	5.29 − 9.66
130	0.4 − 3.4 =	− 4.2	17.64	0.16 − 1.36
131	0.6 + 1.0 =	− 0.2	0.04	0.36 + 0.60
132	0.5 + 0.7 =	− 0.3	0.09	0.25 + 0.35
133	3.2 + 12.9 =	+ 6.4	40.96	10.24 + 41.28
134	4.9 + 16.2 =	+ 6.3	39.69	24.01 + 79.38
135	4.2 + 5.6 =	− 2.9	8.41	17.64 + 23.52
136	1.2 + 10.2 =	+ 7.8	60.84	1.44 + 12.24
137	1.2 − 1.3 =	− 3.7	13.69	1.44 − 1.56
138	3.4 + 5.7 =	− 1.2	1.44	11.56 + 19.38
146	4.0 + 9.6 =	+ 1.5	2.25	16.00 + 38.40
147	1.0 + 4.5 =	+ 2.5	6.25	1.00 + 4.50
148	0.8 − 3.7 =	− 5.3	28.09	0.64 − 2.96
149	1.3 + 0.8 =	− 1.8	3.24	1.69 + 1.04
150	0.8 + 9.8 =	+ 8.2	67.24	0.64 + 7.84
151	1.0 + 1.5 =	− 0.5	0.25	1.00 + 1.50
152	0.9 + 2.0 =	+ 0.2	0.04	0.81 + 1.80
153	3.4 + 5.7 =	− 1.2	1.44	11.56 + 19.38
154	0.9 + 6.5 =	+ 4.7	22.09	0.81 + 5.85
155	0.9 − 2.7 =	− 4.5	20.25	0.81 − 2.43
156	1.6 + 2.6 =	− 0.6	0.36	2.56 + 4.16
157	2.3 + 7.8 =	+ 3.2	10.24	5.29 + 17.94
158	2.0 + 3.1 =	− 0.9	0.81	4.00 + 6.20
159	5.4 + 7.1 =	− 3.8	14.44	29.16 + 38.34
160	1.8 + 6.5 =	+ 2.9	8.41	3.24 + 11.70
161	1.0 − 7.3 =	− 9.3	86.49	1.00 − 7.30
162	0.9 + 7.4 =	+ 5.6	31.36	0.81 + 6.66
163	1.2 + 6.5 =	+ 4.1	16.81	1.44 + 7.80
164	2.2 + 11.2 =	+ 6.8	46.24	4.84 + 24.64
165	2.8 + 9.5 =	+ 3.8	14.44	7.84 + 26.60
34′	3.1x' + 0.6 =	− 5.7	32.49	9.61 + 1.86
35′	2.3 − 1.7 =	− 6.4	40.96	5.29 − 3.91
36′	1.0 + 6.5 =	+ 4.5	20.25	1.00 + 6.50
37′	3.1 + 5.3 =	− 1.0	1.00	9.61 + 16.43
38′	1.0 − 2.0 =	− 4.0	16.00	1.00 − 2.00
39′	0.6 − 1.1 =	− 2.3	5.29	0.36 − 0.66
40′	1.0 + 4.0 =	+ 2.0	4.00	1.00 + 4.00
41′	2.4 + 5.0 =	+ 0.2	0.04	5.76 + 12.00
42′	2.1 + 2.7 =	− 1.5	2.25	4.41 + 5.67
44′	0.7 + 5.4 =	+ 4.0	16.00	0.49 + 3.78
45′	0.9 − 7.9 =	− 9.7	94.09	0.81 − 7.11
46′	1.9 + 10.9 =	+ 7.1	50.41	3.61 + 20.71
47′	2.6 + 6.5 =	+ 1.2	1.44	6.76 + 16.90
48′	2.8 − 5.5 =	− 11.2	125.44	7.84 − 15.40
49′	2.1 + 2.7 =	− 1.5	2.25	4.41 + 5.67
50′	1.7 − 4.1 =	− 7.5	56.25	2.89 − 6.97
51′	2.1 + 6.8 =	+ 2.6	6.76	4.41 + 14.28
52′	1.8 − 2.4 =	− 6.0	36.00	3.24 − 4.32
53′	0.8 + 3.0 =	+ 1.4	1.96	0.64 + 2.40
54′	1.0 + 1.3 =	− 0.7	0.49	1.00 + 1.30
55′	1.5 + 0.7 =	− 2.3	5.29	2.25 + 1.05
56′	2.2 + 5.3 =	+ 0.9	0.81	4.84 + 11.66
57′	2.0 + 5.6 =	+ 1.6	2.56	4.00 + 11.20

Determination of difference of personal erorrs of Assistants Paige and Frost, &c.—Continued.

No. of line.	Kx'	— (P — F) =	v	vv	K² —	(P — F)
58'	0.8	+ 7.0 =	+ 5.4	29.16	0.64	+ 5.60
59'	1.1	+ 2.7 =	+ 0.5	0.25	1.21	+ 2.97
60'	1.0	+ 3.4 =	+ 1.4	1.96	1.00	+ 3.40
61'	2.0	+15.8 =	+11.8	139.24	4.00	+ 31.60
62	3.3	+ 2.1 =	— 4.6	21.16	10.89	+ 6.93
63	1.0	+ 5.5 =	+ 3.5	12.25	1.00	+ 5.50
64	1.8	+ 3.0 =	— 0.6	0.36	3.24	+ 5.40
				3459.59	+ 524.20	+1060.34

Normal equation:

$$+524.20x' + 1060.34 = 0 \qquad x' = -2.02^{\text{mm}}$$

Prob. error of a single observation:

$$r_0 = \pm 0.6745 \sqrt{\frac{3459.59}{119}} = \pm 3.64^{\text{mm}}$$

Prob. error of x':

$$r_{x'} = \pm \frac{r_0}{\sqrt{p_{x'}}} = \pm \frac{3.64}{\sqrt{524.20}} = \pm 0.16^{\text{mm}} \qquad x' = -2.02^{\text{mm}} \pm 0.16^{\text{mm}}$$

Determination of difference of personal errors of Messrs. Paige and Sankee.

No. of line.	Kx'	— (P — S) =	v	vv	K²	— K (P — S)
13'	0.8	— 3.0 =	— 7.9	62.41	0.64	— 2.40
20'	1.8	+15.7 =	+ 4.7	22.09	3.24	+ 28.26
21'	1.9	+11.9 =	+ 0.3	0.09	3.61	+ 22.61
22'	0.8	+ 1.6 =	— 3.3	10.89	0.64	+ 1.28
				95.48	8.13	+ 49.75

Normal equation:

$$8.13x' + 49.75 = 0 \qquad x' = -6.12^{\text{mm}}$$

Prob. error of a single observation:

$$r_0 = \pm .6745 \sqrt{\frac{95.48}{3}} = \pm 3.80^{\text{mm}}$$

Prob. error of x':

$$r_{x'} = \frac{r_0}{\sqrt{p_{x'}}} = \pm \frac{3.80}{\sqrt{8.13}} = \pm 1.33^{\text{mm}} \qquad x' = -6.12^{\text{mm}} \pm 1.33^{\text{mm}}$$

Determination of personal error of Assistant Johnson from results of from Prentiss levels to Greenville.

No. of line.	$2Kx-(n-s)=v'$	$v'v'$	$4K^2-2K(n-s)$	v	vv		$\frac{vv}{2K}$
1....	$5.3x' + 4.1 = + 0.8$	0.64	28.09 + 21.73	+ 2.7	7.29	Rods supported on foot-plates.	1.38
2....	$6.9 + 6.3 = + 2.0$	4.00	47.61 + 43.47	+ 4.5	20.25		2.93
3....	$2.9 - 3.8 = - 5.6$	31.36	8.41 — 11.02	— 4.6	21.16		7.30
4....	$2.2 - 0.3 = - 1.7$	2.89	4.84 — 0.66	— 0.9	0.81		0.37
5....	$2.0 - 0.7 = - 1.9$	3.61	4.00 — 1.40	— 1.2	1.44		0.72
6....	$2.4 + 4.1 = + 2.6$	6.76	5.76 + 9.84	+ 3.5	12.25		5.10
7....	$1.0 - 1.9 = - 2.5$	6.25	1.00 — 1.90	— 2.2	4.84		4.84
8....	$6.9 + 5.3 = + 1.0$	1.00	47.61 + 36.57	+ 3.5	12.25		1.77
9....	$5.2 + 14.2 = + 11.0$	121.00	27.04 + 73.84	+12.8	163.84		31.51
10....	$1.0 + 1.0 = + 0.4$	0.16	1.00 + 1.00	+ 0.7	0.49		0.49
11....	$9.1 + 0.3 = - 5.3$	28.09	82.81 + 2.73	— 2.7	7.29		0.60
12....	$3.7 - 3.9 = - 6.2$	38.44	13.69 — 14.43	— 4.9	24.01		6.49
13....	$5.3 + 10.4 = + 7.1$	50.41	28.09 + 55.12	+ 9.0	81.00		15.28
14....	$4.2 + 0.3 = - 2.9$	8.41	17.64 — 1.26	— 1.4	1.96		0.47
15....	$5.2 + 2.7 = - 0.5$	0.25	27.04 + 14.04	+ 1.4	1.96		0.38
16....	$6.8 + 3.4 = - 0.8$	0.64	46.24 + 23.12	+ 1.6	2.56		0.38
17....	$1.8 + 0.4 = - 0.7$	0.49	3.24 + 0.72	— 0.1	0.01		0.00
18....	$0.5 + 1.8 = + 1.5$	2.25	0.25 + 0.90	+ 1.7	2.89		5.78
19....	$3.7 + 2.0 = - 0.3$	0.09	13.69 + 7.40	+ 1.0	1.00		0.27
20....	$1.0 - 1.5 = - 2.1$	4.41	1.00 — 1 50	— 1.8	3.24		3.24
21....	$8.2 + 6.2 = + 1.1$	1.21	67.24 + 50.84	+ 4.1	16.81		2.05
22....	$3.1 - 3.0 = - 4.9$	24.01	9.61 — 9.30	— 3.8	14.44		4.66
		336.37	485.90 +299.85		401.79		96.21
	v''	$v''v''$					
23....	$3.7x'' + 4.9 = + 6.2$	38.44	13.69 + 18.13	+ 3.9	15.21	Rods supported on stakes.	4.11
24....	$0.5 - 1.0 = - 0.8$	0.64	0.25 — 0.50	— 1.1	1.21		2.42
25....	$5.5 + 0.7 = + 2.6$	6.76	30.25 + 3.85	— 0.7	0.49		0.09
26....	$7.1 - 5.0 = - 2.5$	6.25	50.41 — 35.50	— 6.8	46.24		6.51
27....	$8.2 + 3.4 = + 6.3$	39.69	67.24 + 27.88	+ 1.3	1.69		0.21
28....	$1.6 - 0.2 = + 0.4$	0.16	2.56 — 0.32	— 0.6	0.36		0.22
29....	$3.3 - 4.4 = - 3.2$	10 24	10.89 — 14.52	— 5.3	28.09		8.51
30....	$3.5 + 1.6 = + 2.8$	7.84	12.25 + 5.60	+ 0.7	0.49		0.14
31....	$2.9 - 1.0 = 0.0$	0.00	8.41 — 2.90	— 1.8	3.24		1.12
32....	$4.0 + 2.5 = + 3.9$	15.21	16.00 + 10.00	+ 1.5	2.25		0.56
33....	$2.3 - 0.4 = + 0.4$	0.16	5.29 — 0.92	— 1.0	1.00		0.43
34....	$6.9 - 11.8 = - 9.4$	88.36	47.61 — 81.42	—13.6	184.96		26.80
35....	$3.8 - 5.0 = - 3.7$	13.69	14.44 — 19.00	— 6.0	36.00		9.47
36....	$1.7 - 4.0 = - 3.4$	11.56	2.89 — 6.80	— 4.4	19.36		11.39
37....	$1.2 - 1.3 = - 0.9$	0.81	1.44 — 1.56	— 1.6	2.56		2.13
		239.81	283.62 — 97.98		744.94		74.11

Normal equations:

$$+485.90x' + 299.85 = 0 \qquad\qquad +283.62x'' - 97.98 = 0$$

$$x' = -\overset{\text{mm}}{0.62} \qquad\qquad x'' = +\overset{\text{mm}}{0.35}$$

Prob. error of a single observation:

$$r_o' = \pm 0.6745\sqrt{\frac{336.37}{21}} = \pm \overset{\text{mm}}{2.70} \qquad\qquad r_o'' = \pm 0.6745\sqrt{\frac{239.81}{14}} = \pm \overset{\text{mm}}{2.79}$$

Prob. error of unknown quantity:

$$r_x' = \frac{r_o'}{\sqrt{p_x'}} = \pm \frac{2.70}{\sqrt{485.90}} = \pm \overset{\text{mm}}{0.12} \qquad\qquad r_x'' = \frac{r_o''}{\sqrt{p_x'}} = \pm \frac{2.79}{\sqrt{283.62}} = \pm \overset{\text{mm}}{0.17}$$

$$x' = -\overset{\text{mm}}{0.62} \pm \overset{\text{mm}}{0.12} \qquad\qquad x'' = +\overset{\text{mm}}{0.35} \pm \overset{\text{mm}}{0.17}$$

Supposing no change in unknown quantity, we have the normal equation:

$$+769.52\,x + 201.87 = 0 \qquad\qquad x = -\overset{\text{mm}}{0.26}$$

$$r_o = \pm 0.6745\sqrt{\frac{744.94}{36}} = \pm \overset{\text{mm}}{3.07} \qquad\qquad r_x = \pm\frac{r_o}{\sqrt{p_x}} = \pm \frac{3.07}{\sqrt{769.52}} = \pm 0.11$$

$$x = -\overset{\text{mm}}{0.26} \pm \overset{\text{mm}}{0.11}$$

Determination of relative personal equation of Assistants Johnson and Ferguson from the results of that portion of the line from Keokuk, Iowa, to Grafton, Ill., lying between temporary bench-marks 65 *and* 151.

B. M.	Kx′	(J—F)		v	vv	K²	K(J—F)
66	2.4x′	− 0.2	=	− 0.7	0.49	5.76	− 0.48
67	2.8	+ 2.2	=	+ 0.5	0.25	7.84	+ 6.16
68	0.8	+ 2.8	=	+ 2.3	5.29	0.64	+ 2.24
70	2.6	+ 6.9	=	+ 5.3	28.09	6.76	+ 17.94
73	3.3	+ 1.9	=	− 0.1	0.01	10.89	+ 6.27
75	4.2	− 2.0	=	− 4.6	21.16	17.64	− 8.40
78	2.5	+ 1.7	=	+ 0.2	0.04	6.25	+ 4.25
79	1.2	+ 1.5	=	+ 0.8	0.64	1.44	+ 1.80
23	2.0	+ 3.5	=	+ 2.3	5.29	4.00	+ 7.00
24	1.4	+ 1.8	=	+ 0.9	0.81	1.96	+ 2.52
82	2.3	− 0.5	=	− 1.9	3.61	5.29	− 1.15
85	2.6	+ 3.2	=	+ 1.6	2.56	6.76	+ 8.32
25	1.4	+ 1.7	=	+ 0.8	0.64	1.96	+ 2.38
87	1.1	− 0.7	=	− 1.4	1.96	1.21	− 0.77
88	1.2	+ 4.9	=	+ 4.2	17.64	1.44	+ 5.88
89	1.8	+ 3.2	=	+ 2.1	4.41	3.24	+ 5.76
91	1.6	+ 2.1	=	+ 1.1	1.21	2.56	+ 3.36
92	1.3	+ 3.6	=	+ 2.8	7.84	1.69	+ 4.68
94	0.9	+ 1.4	=	+ 0.8	0.64	0.81	+ 1.26
95	1.0	− 0.2	=	− 0.8	0.64	1.00	− 0.20
97	2.0	− 1.7	=	− 2.9	8.41	4.00	− 3.40
99	2.4	0.0	=	− 1.5	2.25	5.76	0.00
101	2.6	+ 4.8	=	+ 3.2	10.24	6.76	+ 12.48
102	2.0	+ 1.7	=	+ 0.5	0.25	4.00	+ 3.40
31	1.4	+ 0.7	=	− 0.2	0.04	1.96	+ 0.98
104	1.0	+ 1.7	=	+ 1.1	1.21	1.00	+ 1.70
106	3.4	− 4.2	=	− 6.3	39.69	11.56	− 14.28
32	0.3	+ 2.7	=	+ 2.5	6.25	0.09	+ 0.81
108	1.7	+ 0.2	=	− 0.8	0.64	2.89	+ 0.34
109	1.3	+ 3.8	=	+ 3.0	9.00	1.69	+ 4.94
33	1.3	+ 0.6	=	− 0.2	0.04	1.69	+ 0.78
111	1.4	+ 0.1	=	− 0.8	0.64	1.96	+ 0.14
113	3.0	− 2.5	=	− 4.4	19.36	9.00	− 7.50
114	1.2	+ 3.4	=	+ 2.7	7.29	1.44	+ 4.08
115	1.0	+ 2.1	=	+ 1.5	2.25	1.00	+ 2.10
116	1.1	− 3.6	=	− 4.3	18.49	1.21	− 3.96
35	2.8	+ 4.7	=	+ 3.0	9.00	7.84	+ 13.16
119	1.0	+ 1.3	=	+ 0.7	0.49	1.00	+ 1.30
36	1.4	− 2.4	=	− 3.3	10.89	1.96	− 3.36
123	3.3	+ 2.2	=	+ 0.2	0.04	10.89	+ 7.26
124	1.0	+ 3.6	=	+ 3.0	9.00	1.00	+ 3.60
37	0.7	− 1.9	=	− 2.3	5.29	0.49	− 1.33
125	1.4	+ 5.1	=	+ 4.2	17.64	1.96	+ 7.14
126	0.7	− 1.0	=	− 1.4	1.96	0.49	− 0.70
127	2.0	+ 1.2	=	0.0	0.00	4.00	+ 2.40
128	0.8	+ 0.4	=	− 0.1	0.01	0.64	+ 0.32
129	1.4	− 0.3	=	− 1.2	1.44	1.96	− 0.42
38	1.4	− 0.8	=	− 1.7	2.89	1.96	− 1.12
130	1.5	+ 4.4	=	+ 3.5	12.25	2.25	+ 6.60
131	1.0	+ 2.6	=	+ 2.0	4.00	1.00	+ 2.60
132	2.1	− 0.7	=	− 2.0	4.00	4.41	− 1.47
40	0.5	+ 2.3	=	+ 2.0	4.00	0.25	+ 1.15
133	1.4	− 1.8	=	− 2.7	7.29	1.96	− 2.52
135	3.0	+ 2.9	=	+ 1.0	1.00	9.00	+ 8.70
136	1.0	+ 4.0	=	+ 3.4	11.56	1.00	+ 4.00
137	0.8	+ 0.2	=	− 0.3	0.09	0.64	+ 0.16
138	0.9	+ 2.3	=	+ 1.7	2.89	0.81	+ 2.07
139	1.6	− 2.4	=	− 3.4	11.56	2.56	− 3.84
140	0.7	+ 2.5	=	+ 2.1	4.41	0.49	+ 1.75
141	1.6	+ 4.7	=	+ 3.7	13.69	2.56	+ 7.52
141½	0.9	+ 3.0	=	+ 2.4	5.76	0.81	+ 2.70
143	2.1	+ 3.3	=	+ 2.0	4.00	4.41	+ 6.93
145	2.5	+ 1.0	=	− 0.6	0.36	6.25	+ 2.50
146	0.5	+ 0.3	=	0.0	0.00	0.25	+ 0.15
148	2.1	+ 0.1	=	− 1.4	1.96	4.41	− 0.21
150	2.5	+ 1.3	=	− 0.2	0.04	6.25	+ 3.25
151	0.3	+ 0.6	=	+ 0.4	0.16	0.09	+ 0.18
					376.94	+ 228.74	+ 141.90

Normal equation:

$$228.74x' + 141.90 = 0 \qquad x' = \overset{\text{mm}}{-0.62}$$

$$\pm .6745\sqrt{\frac{376.94}{66}} = \pm \overset{\text{mm}}{1.61} \qquad r_x = \pm\frac{1.61}{\sqrt{228.74}} = \pm \overset{\text{mm}}{0.11}$$

$$x' = \overset{\text{mm}}{-0.62} \pm \overset{\text{mm}}{0.11}$$

Discrepancies between north and south lines of levels between Keokuk, Iowa, and Fulton, Ill., by Assistants J. B. Johnson and O. W. Ferguson.

O. W. Ferguson, observer.				J. B. Johnson, observer.			
No. of bench-mark.	Distance.	n—s		No. of bench-mark.	Distance.	n—s	
		Pins.	Foot-plates.			Pins.	Foot-plates.
1*	1.7	− 1.1	− 8.9	2*	1.4	+ 2.7	+ 2.7
5*	1.6	+ 0.6	+ 4.3	U. S. 1*	0.6	− 2.6	− 0.4
6*	1.2	+ 0.1		3*	2.4	− 0.2	− 4.4
9	1.7	− 1.3		7	1.7	− 2.9	
10	1.6	+ 1.9		8	1.2	− 0.2	
12	0.8	− 0.8		U. S. 9	0.4	− 3.5	
13	1.6	+ 0.6		11	2.2	− 5.0	
17	0.9	+ 0.1		14	1.6	− 2.9	
U. S. 4	1.1	+ 0.6		15	1.4	+ 0.8	
U. S. 5	0.9	− 1.5		16	1.6	− 3.8	
U. S. 6	1.4	+ 2.7		18	1.5	+ 2.8	
22	1.7	− 0.9		19	1.5	− 3.7	
23	1.6	+ 2.8		20	1.7	− 1.2	
24	1.7	− 1.4		29*	1.5	− 3.9	− 0.9
26	0.8	+ 0.5		30*	0.6	− 0.3	− 0.8
27	1.6	− 3.9		31*	0.2	+ 0.7	− 0.2
28	1.4	− 0.1		35*	1.6	− 3.1	+ 1.3
32	0.9	− 3.7		36*	1.6	+ 5.6	− 2.6
33	0.8	− 1.6		38*	0.8	− 4.5	− 1.8
34	1.4	+ 0.2		39*	0.8	− 5.3	− 2.8
U. S. 10	1.5	+ 4.3		42*	1.5	− 5.8	− 2.3
37	1.2	− 3.6		43*	1.3	+ 3.2	+ 0.6
40	1.3	− 1.0		U. S. 13*	1.1	+ 2.0	+ 0.8
41	1.5	+ 3.3		47½	1.1		+ 3.2
44	1.6	+ 3.5		48	0.5		− 0.4
45	1.7	− 1.0		51	0.9		+ 1.1
46	1.4	− 1.1		52	0.8		− 1.9
49	1.3	+ 1.2		53	0.9		+ 2.2
U. S. 15	0.4	+ 1.2		54	1.4		+ 5.3
50	1.3	+ 2.1		56 B	0.8	+ 1.5	
55	1.2	− 3.8		57	0.5	+ 1.5	
56	1.4	− 2.7		58*	1.0	+ 4.1	− 1.1
56 A	1.9	+ 0.6		64	0.7		+ 0.1
59	1.3	− 2.3		65	1.0		− 1.8
60	1.2	− 1.3		66	1.1		− 0.8
61	1.2	− 2.1		69	1.2		+ 1.9
62	1.6	− 3.0		70	1.4		− 0.8
63	0.8	+ 2.0		71	1.1		+ 0.9
67*	1.7	+10.0	+ 3.3	74	1.1		+ 5.4
68	0.6		+ 2.2	75	1.3		− 0.8
72	1.3		− 0.3	76	0.8		+ 0.6
73	2.5		+ 3.7	77	1.8		+ 0.9
78	1.3		+ 1.3	84	1.5		− 4.3
79	1.1		+ 1.0	85	1.3		− 2.6
80	0.4		+ 0.7	86	1.3		+ 1.2
81	0.5		+ 1.3	87	1.1		+ 3.7
82	1.5		+ 3.3	88	1.0		+ 2.5
83	1.2		− 0.4	90	0.2		+ 1.8
89	3.4		+ 0.6	95*	1.2	− 3.4	− 4.8
U. S. 22	0.3		+ 0.6	96	1.0	− 1.2	
92	0.1	+ 0.1		97	0.9	+ 1.7	
93*	1.1	+ 1.3	− 5.6	100	1.3	+ 1.1	
94*	0.9	+ 0.3	− 0.5	101	0.8	− 1.8	
98	1.9	+ 2.8		104	0.2	+ 0.4	
99	1.2	+ 0.8		106	1.6	− 4.5	
102	0.6	− 1.8		107	1.0	− 6.0	
103	0.1	+ 1.1		110	1.7	+ 4.0	
107	1.0	− 2.2		111	1.5	+ 1.0	
108	1.6	− 0.7		117	1.4	+ 2.2	
109	1.1	+ 0.1		118	0.9	− 3.8	

Discrepancies between north and south lines of level, &c.—Continued.

O. W. Ferguson, observer.				J. B. Johnson, observer.			
No. of bench-mark.	Distance	n—s		No. of bench-mark.	Distance.	n—s	
		Pins.	Foot-plates.			Pins.	Foot-plates.
112	0.7	+ 8.6		119	1.3	+ 0.9	
113	0.7	− 0.2		124	0.6	− 0.4	
114	0.8	+ 2.9		125	1.0	− 2.2	
115	1.0	+ 2.6		126	0.9	− 2.2	
116	0.5	+ 1.1		127	0.6	+ 1.1	
120	1.7	+ 1.8		128	2.2	+ 2.5	
121	0.6	− 2.0		132	1.8	+ 1.2	
122	1.2	− 8.8		133	1.3	+ 3.5	
123	1.8	− 0.1		137	1.8	+ 1.3	
129	1.0	+ 3.2		138	1.2	− 0.6	
U. S. 29	0.3	+ 0.6		139	1.5		− 0.6
130	1.1	− 0.5		U. S. 34	0.7		− 1.0
131	1.6	− 5.1		142	0.7		+ 0.5
134	1.5	− 3.1		143	1.2		− 2.6
U. S. 31	1.1	− 0.6		35 A	0.9		− 0.8
135	1.0	+ 1.6		147	0.5		− 1.4
136	0.5	+ 2.5		148	0.7		− 2.9
140	1.4		+ 1.6	151	0.5		− 0.7
141	1.1		− 2.4	152	1.4		+ 1.8
144	1.1		− 2.5	156	1.0		− 1.5
145	0.7		− 0.1	157	0.6		− 2.1
146	1.1		+ 3.5	161	1.4		+ 3.5
149	0.7		+ 0.4	162	1.1		+ 4.4
150	1.8		+ 0.1	163	1.0		+ 4.5
153	0.3		+ 0.2	168	1.5		− 0.8
154	0.5		− 2.9	170	1.1		+ 0.8
155	0.6		− 0.8	173	0.7		+ 1.0
158	1.0		− 2.6	175	1.8		+ 2.6
159	0.6		− 1.1	179	1.1		− 3.2
160	0.2		− 2.0	180	1.1		+ 3.9
164	1.2		− 2.5	181	1.0	+ 0.1	
165	1.2		+ 0.4	182	1.0	+ 1.4	
166	1.8		+ 8.2	186	0.8	− 0.3	
171	1.4		+ 1.6	187	1.2	+ 0.6	
172	0.8		+ 0.5	188	0.7	+ 2.0	
176	2.0		− 0.1	191	1.3	+ 4.7	
177	0.9		− 3.7	192	1.9	+ 2.1	
178	0.8		− 0.7	194	0.9	+ 2.8	
183	0.9	+ 0.5	− 8.0	195	1.4	− 0.1	
184	1.8	+ 3.7	− 4.9	199	1.3	+ 0.5	
189	0.9	+ 1.9		200	1.2	+ 0.9	
190	1.2	+ 4.2		201	0.8	− 1.8	
192 A	2.1	− 1.8		202	2.0		+ 3.2
193	0.7	− 1.5		203	1.0		− 0.4
196	2.9	− 3.2		207	1.4		+ 3.7
197	1.4	+ 4.5	+ 0.2	208	1.4		+ 1.0
198	1.6	+ 4.2		63 A	2.0		+ 1.3
204	1.0		− 2.6	212	1.0		− 3.5
205	0.8		+ 1.0	213	1.0		+ 3.6
206	2.0		− 1.1				
209	2.3		+ 0.8				
210	1.0		− 1.8				
211	0.7		− 1.6				

	O. W. Ferguson		J. B. Johnson	
	+ 83.2 − 63.8	+ 35.8 − 51.1	+ 60.9 − 76.2	+ 71.0 − 56.5
	+ 19.4	− 15.3	− 15.3	+ 14.5
	+ 4.1		− 0.8	
Positive discrepancies	41	23	31	32
Negative discrepancies	34	28	29	32
	m. m.	m. m.	m. m.	m. m.
Mean discrepancies	1.96	1.89	2.28	1.99

Discrepancies between north and south lines leveled by Assistant Paige between Columbus and Memphis and Friar's Point and Prentiss.

No. of line.	[2 K]	[*s*—*n*]	No. of line.	[2 K]	[*s*—*n*]
	k. m.	*m. m.*		*k. m.*	*m. m.*
3	0.8	+ 5.4	43	69.9	−174.8
4	2.9	+ 6.8	44	74.4	−180.4
9	4.3	+ 2.4	50	75.7	−180.8
12	6.1	− 7.9	51	80.9	−177.7
13	7.0	− 7.2	66	88.8	−185.7
14	9.3	− 11.3	68	90.7	−190.4
15	15.6	− 25.6	82	92.8	−193.8
16	17.8	− 40.6	83	95.1	−198.9
17	18.1	− 37.4	84	97.0	−201.3
19	22.5	− 58.9	85	98.3	−208.8
20	31.4	− 71.2	86	104.1	−216.6
21	33.6	− 75.5	94	105.5	−226.3
22	39.7	− 80.7	95	109.4	−245.3
23	42.7	− 87.3	96	112.8	−251.9
24	44.8	− 96.0	99	115.5	−266.7
25	48.3	−102.8	101	118.1	−279.1
28	49.6	−104.7	130	118.8	−278.7
29	51.8	−122.5	10′	122.3	−286.8
30	55.8	−147.0	11′	124.6	−280.9
31	61.7	−161.5	18′	126.8	−286.8
32	62.3	−163.4	23′	129.4	−298.0
35	66.0	−166.7	27′	131.4	−300.1
41	67.4	−170.5	36′	133.4	−305.8

Discrepancies between results of levels by Assistants Paige and Frost from leveling between Columbus and Memphis and Friar's Point and Prentiss.

No. of line.	[K]	[F—P]	No. of line.	[K]	[F—P]
26	2.0	+ 5.9	129	108.3	+278.7
27	4.4	+ 22.2	130	108.7	+270.8
33	6.4	+ 30.4	131	109.3	+271.8
34	8.0	+ 28.4	132	109.8	+272.0
37	10.4	+ 40.7	133	113.0	+284.9
38	13.4	+ 55.8	134	117.9	+301.1
39	18.0	+ 62.4	135	122.1	+306.7
40	21.4	+ 66.1	136	123.3	+316.9
41	22.1	+ 63.7	137	124.5	+315.6
42	26.1	+ 54.6	138	127.9	+321.8
43	27.4	+ 55.3	146	131.9	+330.9
45	29.7	+ 49.9	147	132.9	+335.4
48	33.6	+ 58.0	148	133.7	+331.7
49	34.5	+ 50.8	149	135.0	+332.5
52	36.1	+ 64.4	150	135.8	+342.8
53	37.1	+ 66.9	151	136.8	+343.8
54	38.6	+ 77.2	152	137.7	+345.8
55	39.8	+ 84.8	153	141.1	+351.5
56	41.1	+ 88.8	154	142.0	+358.0
57	41.9	+ 96.3	155	142.9	+355.8
59	43.4	+ 95.0	156	144.5	+357.9
60	45.4	+ 99.1	157	146.8	+365.7
61	45.9	+ 99.2	158	148.8	+368.8
62	48.3	+107.6	159	154.2	+375.9
65	48.8	+103.8	160	156.0	+382.4
66	52.7	+121.4	161	157.0	+375.1
67	54.1	+131.0	162	157.9	+382.5
69	56.4	+123.5	163	159.1	+389.0
70	60.2	+135.9	164	161.3	+400.2
71	61.2	+143.9	165	164.1	+409.7
72	61.4	+145.7	34′	167.2	+410.3
73	65.7	+150.3	35′	169.5	+408.6
74	66.2	+155.4	36′	170.5	+415.1
75	67.8	+165.6	37′	173.6	+420.4
97	70.7	+160.7	38′	174.6	+418.4
98	72.9	+162.1	39′	175.2	+417.3
99	74.3	+167.6	40′	176.2	+421.3
100	76.5	+171.0	41′	178.6	+426.3
101	77.8	+181.4	42′	180.7	+429.0
102	78.7	+186.6	44′	181.4	+434.4
103	79.8	+188.9	45′	182.3	+426.5
104	81.3	+189.8	46′	184.2	+437.4
105	82.6	+195.4	47′	186.8	+443.9
106	84.2	+200.8	48′	189.6	+438.4
107	85.9	+211.5	49′	191.7	+441.1
108	87.5	+209.3	50′	193.4	+437.0
109	88.5	+216.3	51′	195.5	+443.8

Discrepancies between results of levels by Assistants Paige and Frost, &c.—**Continued.**

No. of line.	[K]	[F—P]	No. of line.	[K]	[F—P]
110	89.5	+225.3	52′	197.3	+441.4
117	91.4	+220.8	53′	198.1	+444.4
118	92.3	+229.4	54′	199.1	+445.7
119	92.8	+238.5	55′	200.6	+446.4
120	94.2	+244.2	56′	202.8	+451.7
121	97.0	+246.9	57′	204.8	+457.3
122	97.9	+255.2	58′	205.6	+464.8
123	100.1	+260.5	59′	206.7	+467.0
124	101.3	+270.7	60′	207.7	+470.4
125	102.6	+269.4	61′	209.7	+486.2
126	103.8	+274.1	62′	213.0	+488.3
127	104.8	+276.4	63′	214.0	+493.8
128	106.0	+277.9	64′	215.8	+496.8

Discrepancies between north and south lines of levels, run by L. L. Wheeler, between Austin and Friar's Point, Miss.

B. M.	[K]	[s—n]	B. M.	[K]	[s—n]
U. S. 1	0.0	0.0	U. S.	21.0	+16.8
1	1.6	+ 2.8	14	23.1	+20.8
2	2.7	+ 2.9	15	23.7	+17.0
3	3.6	+ 5.8	16	25.8	+15.5
4	4.6	+ 5.1	17	27.8	+19.0
5	5.9	+ 9.3	18	29.1	+21.2
6	6.9	+10.5	19	31.1	+18.5
7	7.9	+ 9.4	20	31.9	+19.4
8	8.7	+ 9.4	21	34.4	+23.2
9	10.8	+12.6	22	36.4	+23.0
10	12.5	+12.8	U. S.	36.9	+23.6
11	13.6	+13.6	23	39.9	+32.3
12	15.6	+17.1	24	42.2	+34.0
U. S.	16.5	+16.8	U. S.	43.5	+36.5
13	19.7	+17.6			

Precise levels from Keokuk, Iowa, to Grafton, Ill.

B. M.	Distance.	S.—N.	[S.—N.]	B. M.	Distance.	S.—N.	[S.—N.]
	km.	*m. m.*	*m. m.*		*km.*	*m. m.*	*m. m.*
66	112.86	—0.2	— 0.2	115	176.76	+2.1	+52.8
67	115.61	+2.2	+ 2.0	116	177.85	—3.6	+48.7
68	116.88	+2.8	+ 4.8	35	180.63	+4.7	+53.3
70	119.02	+6.9	+11.7	119	181.60	+1.3	+54.6
73	122.29	+1.9	+13.6	36	182.96	—2.4	+52.2
76	126.51	—2.0	+11.6	123	186.24	+2.2	+54.4
78	129.02	+1.7	+13.3	124	187.26	+3.6	+57.8
79	130.26	+1.5	+14.8	37	187.92	—1.9	+55.9
23	132.30	+3.5	+18.3	125	189.28	+5.1	+61.0
24	133.74	+1.8	+20.1	126	189.99	—1.0	+60.0
82	136.00	—0.5	+19.6	127	191.95	+1.2	+61.2
85	138.59	+3.2	+22.8	128	192.72	+0.4	+61.6
25	140.02	+1.7	+24.5	129	194.10	—0.3	+61.3
87	141.07	—0.7	+23.8	38	195.45	—0.8	+60.5
88	142.20	+4.9	+28.7	130	196.93	+4.4	+64.9
89	144.08	+3.2	+31.9	131	197.93	+2.6	+67.5
91	145.68	+2.1	+34.0	132	200.00	—0.7	+66.8
92	147.02	+3.6	+37.7	40	200.51	+2.3	+69.1
94	147.95	+1.4	+39.1	133	201.87	—1.8	+67.3
*95	148.93	—0.2	+38.9	135	204.91	+2.9	+70.2
97	152.75	—1.7	+37.2	136	205.92	+4.0	+74.2
99	155.15	0.0	+37.2	137	206.74	+0.2	+74.4
101	157.80	+4.8	+42.0	138	207.62	+2.3	+76.7
102	159.76	+1.7	+43.7	139	209.24	—2.4	+74.3
31	161.18	+0.7	+44.4	140	209.93	+2.5	+76.8
104	162.18	+1.7	+46.1	141	211.52	+4.7	+81.5
106	165.62	—4.2	+41.9	141½	212.41	+3.0	+84.5
32	165.96	+2.7	+44.6	143	214.52	+3.3	+87.8
108	167.64	+0.2	+44.8	145	217.02	+1.0	+88.8
109	168.93	+3.8	+48.6	146	217.53	+0.3	+89.1
33	170.24	+0.6	+49.2	148	219.65	—0.1	+89.2
111	171.62	+0.1	+49.3	150	222.15	+1.3	+90.5
113	174.58	—2.5	+46.8	151	222.48	+0.6	+91.1
114	175.74	+3.4	+50.2				

*Between 95 and 97 there is a river crossing.

Discrepancies between north and south lines of levels run by Assistant Ferguson between Grafton and Cairo. The lines beyond T. B. M. 240 are not used because methods are changed.

B. M.	2 (distance).	S.—N.	2 (sum distance).	Sum (S.—N.).	B. M.	2 (distance).	S.—N.	2 (sum distance).	Sum (S.—N.).
20	2.2	—6.5	2.2	— 6.5	191	2.0	— 4.9	38.1	— 42.6
27	2.9	—0.7	5.1	— 7.2	192	1.2	— 1.1	39.3	— 43.7
33	1.7	+6.3	6.8	— 0.9	194	2.5	— 6.7	41.8	— 50.4
44	3.6	—4.5	10.4	— 5.4	195	2.5	— 2.5	44.3	— 52.9
45	1.7	+4.8	12.1	— 0.6	196	2.7	— 9.2	47.0	— 62.1
85	1.7	—3.3	13.8	— 3.9	197	1.8	— 3.8	48.8	— 65.9
87	2.3	—1.9	16.1	— 5.8	208	2.2	+ 0.3	51.0	— 65.6
157	1.1	—4.7	17.2	—10.5	209	2.4	— 9.3	53.4	— 74.9
160	3.0	+0.1	20.2	—10.4	217	2.5	— 5.2	55.9	— 80.1
163	3.1	—3.4	23.3	—13.8	218	2.5	— 9.4	58.4	— 89.5
28	1.1	—0.5	24.4	—14.3	232	4.7	— 7.5	63.1	— 97.0
40	2.4	—7.2	26.8	—21.5	233	0.8	— 5.7	63.9	—102.7
46	1.1	—2.0	27.9	—23.5	235	4.0	—20.2	67.9	—122.9
31	2.1	—7.7	30.0	—31.2	236	2.1	—13.2	70.0	—136.1
51	0.6	+1.2	30.6	—30.0	239	1.8	—11.4	71.8	—147.5
173	0.7	—1.5	31.3	—31.5	240	2.2	—12.8	74.0	—160.3
84	4.8	—6.2	36.1	—37.7					

APPENDIX D.

REPORTS OF CHIEFS OF PARTIES, UPON FIELD WORK OF TOPOGRAPHY AND HYDROGRAPHY, 1882–'83.

1.—REPORT OF ASSISTANT ENGINEER J. A. OCKERSON, ARKANSAS CITY TO GREENVILLE AND NATCHEZ TO BAYOU SARA.

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., September 15, 1883.

SIR: I have the honor to submit the following report on the field operations under my direction during the season of 1882 and 1883.

In accordance with your instructions, the party left Saint Louis on September 12, 1882, for Arkansas City, arriving at the latter point on September 15. The quarter boats Mississippi and Louisiana and the tug Frolic, which were assigned to the party, arrived on the 17th, and work was begun at once. The organization of the party was as follows: J. A. Ockerson, chief of party; topographers, B. H. Colby, N. B. Craig, J. C. Quintus, L. C. Jones, F. Felkel, G. M. Anderson, and W. Garvin; hydrographers, C. W. Clark and D. S. Flower; levelers, F. B. French and R. C. Hoyer; draughtsman, Edwin J. Jolley. E. E. Haskell was attached to the party until October 19th, when he received orders to report for duty to Assistant L. L. Wheeler at Vicksburg. F. Felkel and G. M. Anderson joined the party on October 16, and W. Garvin on October 28. R. B. Whiteford, who started out with the party, was disabled, and was ordered to Saint Louis on September 29. The laboring force was about the same as the previous season.

The topographical work began on the right bank at Arkansas City, and on the left bank at Offutt's Landing, where the work of last season ended.

The survey was completed on November 4 to Barnes' Landing, about 2 miles above Greenville, where it joins the work of Assistant G. Y. Wisner.

On the completion of this reach the party was ordered to Natchez to resume the survey and continue down the river. The party left Greenville with quarter-boats in tow of the tug Frolic on November 5, and arrived at Natchez on November 8.

The survey was completed to Bayou Sara, where it joined the work of Assistant C. M. Winchell, on February 19, when orders were received to disband the party and return to Saint Louis.

The stage of the river was unusually favorable for surveys during the entire season. At the beginning of the work there were many places which were impassable from the deposits of mud left by the previous high water, and in such cases considerable detail was necessarily omitted.

From the beginning of the season till the middle of October there was a great deal of sickness in the party. At one time one-third of the entire party were sick with malarial fevers. Of the original party, twenty were discharged before October 25, on account of sickness. Judging from this experience, it is evident that it is not safe to take the field prior to the middle of October.

There were thirty-three days of rain and fog, or a little more than one-third of the entire season.

The progress of the work is due to the hearty co-operation of my assistants, who are deserving of credit for their fidelity and energy.

TERTIARY TRIANGULATION.

The secondary triangulation was not carried over Spanish Moss Bend, and at other points so many stations had caved into the river, that a tertiary system became necessary over the entire reach above Greenville. Below Natchez the tertiary work became necessary because the data, such as azimuths and lengths of triangle sides, was not furnished to the party.

The tertiary work was always connected with the secondary stations when found, and a comparison has been made with the secondary data on file in this office. The results are given in a table below. The tertiary angles were measured with Würdemann, No. 152, reading to 10 seconds, and Gambey, No. 2, reading to 5 seconds. Angles were read by J. A. Ockerson and B. H. Colby.

Comparison of tertiary with secondary triangulation.

Lines compared.	No. of tertiary triangles.	Tertiary lengths.	Secondary lengths.	Ratio of discrepancies.
		meters.	*meters.*	
Wallwood-Carter	34	1389.67	1389.7	1 in 46323
Winn-Obers	10	2818.4	2819.5	1 in 2562
Wilds-Allway	18	1938.6	1939.0	1 in 4846
Island-Pullen	38	1518.6	1518.2	1 in 3796
S. W. Base-Rock Hill	58	3152.9	3152.6	1 in 10509
Leatherman-Stump	88	1547.2	1547.3	1 in 15472
Stevenson-Douglass	96	2223.8	2223.5	1 in 7412
N. W. Base-St. F. church spire.	25	1389.7	1389.7	Lengths equal.

The following method was used in reading the angles. The system was laid out and the angles generally read in advance of the topographers, so that the lengths of sides and azimuths could be used to check the stadia work. The △ point was marked by a pole about 2 inches in diameter, and bearing a red-and-white flag to distinguish it from the ordinary sounding flags. A strip of white cloth was fastened around the pole near the bottom, to which the pointings were made, thus obviating errors from swaying of the pole in the wind, or from its being out of plumb. In observing, the theodolite was placed on an ordinary instrument tripod centered over the hole, after removing the pole. The angles were read three times on different parts of the limb to check errors of reading. Most of them were measured with Gambey No. 2. No attempt was made to confine the measuring to favorable conditions of atmosphere, but angles were read whenever the target could be seen at all.

Flags can be set and the angles read over a reach of 5 miles a day. Considering the time spent in this work, the results shown are remarkably good.

In view of the desirability of having frequent checks on the stadia work, particularly where there are so many new observers, I would suggest that the topographical parties be required to locate points at intervals of not more than a mile, by means of a tertiary system of triangulation. This system should begin and end on lines of known length, so that it can be checked.

TOPOGRAPHY.

The general scope of the topographical work was the same as last season, a description of which is given in Appendix G, Progress Report of the Mississippi River Commission, 1882. The compass was used in running lines through the woods, as suggested in above report. This method was found to be quite satisfactory, and much more rapid than the transit lines used in former work.

Beyond the prescribed topographical limits there were located the outlines of bluffs, old river lakes and bayous, and the Red River from Cut-off Bayou to the Mississippi River.

HYDROGRAPHY.

Many more soundings were taken than heretofore. Besides the sections normal to the channel, soundings were taken along the line of deepest water. The latter work was preferably done during calm weather, when the sounding boat was allowed to drift along the thread of the current. The deepest water found during the season was 156 feet, the stage of river being about 27 feet below the high water of 1882. This depth was found at two points, one near New Texas, and the other about five miles above Bayou Sara.

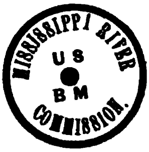
ORDINARY LEVELS.

The levels were based on the primary elevations of the United States Coast and Geodetic Survey. Very few of the Coast Survey stone lines were connected with, as the stones could not be found. Many of them were buried below, or even with the surface of the ground, and no mark was left above the surface to indicate the locality of the bench-mark.

A new form of bench-mark was used for points situated in the woods, some distance from the river, the object being to increase the stability and make them more conspicuous, so they can be easily found.

This bench-mark consisted of a flat stone, 18 inches square and 4 inches thick. The upper surface was dressed smooth, and a hole was drilled in the center, into which a copper bolt was leaded, the end projecting a quarter of an inch above the face of the stone. The stone was marked thus $\begin{matrix}\text{U}&&\text{S}\\&\bullet&\\\text{B}&&\text{M}\end{matrix}$ This was placed three feet below the surface of the ground, with the marked surface up, care being taken to have it horizontal and firm. On this stone, and centered over the copper bolt, a cast iron pipe, 4 inches in diameter, and 5 feet long, was placed, and the dirt tamped in around it. The pipe is large enough to admit a leveling rod. The top is closed with a cap, which is fastened to the pipe by means of a bolt.

The cap is marked as follows:



The elevation of both the top of the pipe and the stone were determined.

The amount of work done is given in a table below.

TOPOGRAPHY.

Number of miles of river surveyed (above Greenville, 36; Natchez to Bayou Sara, 100)	136
Average miles of river surveyed per month	27
Number of square miles of topography (above Greenville, 70½; Natchez to Bayou Sara, 250)	320.5
Average number of square miles per month	64
Number of elevations determined	34293
Average number of elevations per square mile	111
Number of triangulation stations occupied	237
Number of base lines measured with steel tape	3
Number of stone bench-marks set	143

HYDROGRAPHY.

Total number of soundings	23,605
Number of sextant angles read	15,574
Average distance between sections	320^{m}
Number of square miles of hydrography	75
Total number of square miles surveyed	395

Plate 1 shows the portion of the river covered by the survey.

CAVING BANKS.

The rate of caving in the bends between Arkansas City and Greenville during the years 1880 to 1882, as determined by comparing the present position of the shore line with its position when the triangulation was done, is given in a table below.

There being no reliable data for determining the rate of caving below Natchez, this reach has been omitted.

Locality.	Character of banks.	Annual rate of caving.
		Meters.
Yellow Bend 2¼ miles below Arkansas City	Clay and sand	57
Yellow Bend 3½ miles below Arkansas City	do	14
Yellow Bend opposite Port Anderson	Sand and silt	22
Georgetown Bend ½ mile below Offutt's	Clay and sand	89
Georgetown Bend at Eutopia	do	89
Georgetown Bend at Ashbrook Point	Sand and silt	29
Rowdy Bend ¾ of a mile below Gaines Landing	Clay and sand	85
Rowdy Bend 2 miles below Gaines Landing	do	14
Rowdy Bend at Scott's Landing	do	22
Miller's Bend at Morris Landing	do	40
Miller's Bend at Tarpley place	do	28

SAND WAVES.

A minute survey was made of a sand bar near Fairview, La., for the purpose of showing the sand waves which are characteristic of all bars. The bar selected is not an extreme case. There are many which have larger and higher waves, and others which are comparatively smooth. In the latter case the waves have the appearance of a pond whose surface is ruffled by a gentle breeze.

It is evident that these waves are mainly due to the action of the water, as they are frequently found on the lower part of bars composed of silt, which is not movable by the wind. The particles on the above bar are about the size of common building sand. The crests of the waves are smooth curves, which are frequently parallel for several waves in succession.

The bluff part of the wave is on the down-stream side, and is frequently nearly vertical. The slope on the up-stream side is generally very gentle.

A plat of the Fairview Bar, which shows the waves by means of contours one foot apart, and two sections of the bar, is appended herewith. A model, showing the bar in relief, has also been prepared.

LEVEES.

ARKANSAS CITY TO GREENVILLE.

Right bank.—From Arkansas City down ¾ mile the embankment of the L. R. and M. R. R. R. serves the purpose of a levee. Here the railroad turns back, and the embankment of an old abandoned railroad continues along the river for 1½ miles, when it disappears. One and a half miles lower down it again appears and follows along the bank of what was at one time the chute of Island 80, to Gaines Landing, the only break being a small one through which Boggy Bayou passes. At this break the levee is now about 2 miles from the river. A private levee incloses the plantation at Gaines Landing. After following along near the river for ¾ mile below Gaines the levee ends abruptly on the caving bank of Rowdy Bend. This break is about 3 miles long, reaching to a point near Scott Landing. Here the levee divides, and one portion of it runs south about half way across the point, then turns west and runs to Yellow Bayou, forming a back levee for the plantations fronting on Spanish Moss Bend, and turning the water which overflows the banks in Rowdy Bend into Bayou Maçon.

The other part of the levee follows along near the river down to the chute of Island 82, thence down the chute to river on the lower side of the point, thence along river bank again down to near Bellevue Landing. Here it turns and joins the back levee mentioned above. This line is broken in many places, one of the breaks, near Linwood, being about ½ mile long.

The levee begins again ¼ mile below Bellevue and 600 meters from the river, and runs down till it joins the old levee about ½ mile above Luna. The old levee extends above this juncture about a mile. From Luna the levee is continuous for about 4½ miles, when it is again cut off by a caving bank. At Point Chicot Landing it appears again and runs directly back from the river for a distance of 600 meters, where it is again broken, and does not appear till beyond the limits of this survey.

Left bank.—From Offutt's Landing the levee runs almost directly across to a point 1½ miles above Argyle Landing, leaving Ashbrook and Woodstock Points outside. It is 550 meters from the river at the lower part of Miller's Bend. From the point where it strikes the river above Argyle it turns and runs down at a distance of ½ mile from the river in the deepest part of the bend, and continues down behind Island 83 to Greenville.

NATCHEZ TO BAYOU SARA.

Right bank.—From Vidalia the levee runs down near river bank to Whitehall. Here it turns back and runs around Natchez Island, coming near the river again near Crother's Plantation. From latter point it runs about 400 meters from the river till it reaches the head of Saint Catherine's Bend, where it turns and runs directly across Esperance Point to the Pecan plantation, about ½ mile above Green's Landing. A small levee then follows along near the river for a distance of a mile and there ends. From the latter point to Ashley Landing there is no levee. Then comes a piece, badly broken, aggregating 1½ miles long. Below this there is no levee till we reach Fairview, where there are several patches, with a total length of about 1½ miles. At Home Place we again find a small levee 1 mile long, and small patches may be found down as far as Bougère. Then there is no levee till we reach Union Point, where it starts back along the old river bank behind the batture, and continues for about 3 miles. Then comes a break extending to Black Hawk. From this point the levee follows along behind a cypress swamp for about 3 miles, and finally, after numerous breaks, is lost entirely, and no more levee is found till Red River Landing is reached. From latter point it runs along near river to Smithland, where it turns back along bank of Old River, touching the river again at Fleta above New Texas. There is an old levee about 2 miles long lying along bank of old river about opposite Tunica Island and 1 mile from the main river.

From Fleta the levee runs down near the river to Morganza crevasse, where the "Grand Levee" is broken for a distance of 1,200 meters. Below this the levee is continuous down to the end of the survey at Point Coupée, except the "Scott crevasse," which was nearly closed. The breaks on the right bank aggregate about 34 miles.

Left bank.—There is no regular system of levees on the left bank till we reach Tunica Island. From this point down to Bayou Sara there was formerly a levee. This section was known as the Greensburg District. But little of the levee now remains. There are small patches from Greenwood Landing down to Sebastopol, where it disappears entirely, and nothing more is seen of it till we reach a point opposite Morganza. From the latter point it extends down to Hardwick ditch, opposite Stuart's Landing. It begins again at Copps' wood yard and runs down to within half a mile of the mouth of Bayou Sara, where it turns back towards the hills.

There are private levees at other points. Just below Hutchins Landing is a piece about 1½ miles long, which runs behind the plantation from the hills to the river bank.

Behind the Corena plantation, opposite Fairview, is a levee 2½ miles long, which serves to keep out the back water.

Allaway plantation has a small front and back levee 1½ miles long. Artonish plantation above Stamp's Landing, has about 1 mile of levee. Langside plantation has a levee along lower side of Clark's Lake, which is about 1 mile long. On the Angola plantation a levee starts in about opposite Smithland and follows along about a mile from the river for a distance of about 4 miles, when it runs into the bluffs. The locations of the above-described levees may be seen on Plate 1, accompanying this report.

STONE LINE SECTIONS.

In the Report of Mississippi River Commission, Appendix G, page 162, a discussion of river-bank profiles is given. A continuation of the same study has been made to embrace that part of the river lying betweem Arkansas City and Donaldsonville.

The sections of the banks do not differ materially from those heretofore published, until we reach a point near Baton Rouge (Stone line No. 11). From this point down the levees are very close to the edge of the bank, and the land outside of the levee is very often three or four feet higher than that on the inside. This indicates a deposit of that amount since levees were built. Sometimes this deposit reaches nearly to the top of the levee.

The sections of the river bed grow gradually narrower and deeper as we approach Donaldsonville.

Respectfully submitted.

J. A. OCKERSON,
Assistant United States Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission

2.—REPORT OF ASSISTANT ENGINEER C. M. WINCHELL, LAKE PROVIDENCE TO WARRENTON AND BAYOU SARA TO DONALDSONVILLE.

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., June 22, 1883.

SIR: I have the honor to make the following report concerning the work done by the hydrographic and topographic party under my charge during the field season of 1882 and 1883:

In obedience to written instructions from you, I left Saint Louis on September 26, 1882, for Lake Providence, La., to assume charge of the party which had been organized and taken the field under the direction of Assistant G. Y. Wisner. I arrived at Lake Providence October 3.

Previous to this date the party had been engaged in filling up gaps in the last year's survey, which had been skipped on account of the high water of 1882.

The survey was continued with the assistants assigned as follows: Hydrography, C. A. Russell and C. N. Roberts; topography, left bank, G. W. Wood and F. B. Maltby; topography, right bank, J. A. Paige and H. W. Kerr; levels, J. C. Cammack and Moses Greenwood. Recorder J. T. Desmond plotted most of the topographic field-notes, the field-plats being completed by the topographers on rainy days and at other times when they could not work to advantage in the field.

Assistant S. L. Beaumont did some topography and assisted in the plotting until the party began work at Bayou Sara, January 8, when he was made hydrographer, Mr. Russell having resigned December 28.

Assistant J. C. Cammack died in New Orleans December 31, and Recorder C. N. Roberts carried the levels on the left bank from Port Hudson to Donaldsonville, La. Assistant A. L. Arner reported for duty January 12, and was assigned to assist the hydrographic party.

Mr. Cammack was an enthusiast in his profession, a conscientious worker, and exceptionally well informed in the various branches of engineering. By his untimely death the Commission lost a valuable assistant, and his messmates a beloved friend. He was highly esteemed by all who knew him.

The rate of progress of the work was materially lessened during October and November by sickness, nearly every member of the party suffering from fever or chills and fever. B. R. Morgan, steward, died October 13 and was buried on land of Judge Hays, at Hays' Landing, Miss. There were very few new cases of sickness after the first good frosts, but 26 men, out of a party of sixty, were discharged on account of sickness before November 15.

The survey was based on a system of secondary triangulation previously executed by the United States Coast and Geodetic Survey, all intermediate points for delineating the topographic features being located by transit and stadia, the stadia courses being checked by connecting with triangulation stations. A continuous line of levels was run down each bank of the river and numerous points determined to aid the topographers in developing the five-foot contours. The levels are referred to the Memphis datum plane of the Mississippi River Commission, and are checked by connection with precise bench-marks established under direction of the United States Coast and Geodetic Survey.

Stone-line bench-marks were established once in about three miles of river, consisting of four stones (two on each side of the river), set in line at right angles to the channel of the river, the stones furthest back being usually 1,000 to 1,200 meters from the river bank. These lines were so arranged as to pass through a triangulation station on one or both banks of the river, the distance back being determined by stadia. The elevations of the bench-marks were checked by duplicate levels. Two kinds of bench-marks were used, the ones nearest the river being granite posts three feet long and six inches square, set in the ground with their tops projecting about one foot above the surface. The bench-marks set farther from the river consisted of flat stones 18"x 18"x 4", with copper bolt leaded into hole in center of upper surface. This stone was set 2½ feet below the surface of the ground, and an iron pipe five feet long carefully centered over the copper bolt and held in position until the hole was filled and ground tamped around the pipe. The top of the pipe is covered with a cap, which can be removed to admit the leveling rod so that the stone can be reached without disturbing the earth around or over it. The elevations of the top of the copper bolt in the stone, and of the top of the cap on the pipe, were both determined in all cases.

This style of bench-mark is preferable to the stone post, because, having a much broader base and being lighter, its value will not change so much by settling; the flat stone being entirely beneath the surface, will not be in so much danger of accidental disturbance as the stone post which projects above the surface; and, lastly, it can be more easily found, the iron pipe projecting 2½ feet above the ground.

In wooded country the compass and stadia were used for locating points of elevation to develop the five-foot contours. By using the compass, woods and swamps can be examined more rapidly and with less cutting than by the usual method of carrying azimuth, thus considerably reducing the expense of the survey. When these compass lines were connected with the regular stadia courses, or with triangulation stations at both ends, it was found that the work closed with an error of less than 1 in 300.

The survey was completed to Big Bayou, about eight miles below Vicksburg, where Assistant L. L. Wheeler's party began work, December 22. The tug Mignon, which had become disabled, was laid up, and the party was detained at Vicksburg until January 1, 1883, waiting for a boat to move us to Bayou Sara, La.

In obedience to your instructions the party started for Bayou Sara as soon as the iron launch which had been assigned to the party was repaired sufficiently to make the trip.

Work was begun at Bayou Sara January 8, six days having been consumed in getting there from Vicksburg. We were delayed on the way by fog and by the wheel of the launch getting loose, which made it necessary to hoist her out of the water and repair her. A new hub was cast for the wheel at Baton Rouge, but the boiler leaked so badly that the tug was of very little use the rest of the season. The tug Frolic was assigned to the party a short time, which enabled us to get good soundings in the channel below Plaquemine, where they could not well have been obtained from the six-oared cutter, at the then existing high stage of river, on account of the great depth and strong current.

Below Bayou Sara the stone-line bench-marks were not set so far back from the river, because the banks are much more stable, the rate of change in position of the river being much less than it is above Vicksburg.

The survey was completed to Donaldsonville, and connection made with the Coast Survey topography March 17, when the party was discharged, and the assistants who were retained returned to the office in Saint Louis. The quarter-boats Tennessee and Pioneer, the tug Frolic, and the iron launch were turned over to Captain Daft, of the tow-boat Baker, and his receipts taken for the same.

A full description of the organization of the working parties, the number of men required for each party, and the methods of carrying on the work in detail, is given in the Report of the Mississippi River Commission for 1882.

The season's work may be summarized as follows:

Miles of river surveyed	160
Square miles of topography	370
Square miles of hydrography	89
Total area surveyed .... square miles..	459

Discrepancies between precise and ordinary levels.

Between P. B. M's.	Distance.	Discrepancies.	Observer.
	Miles.	*Feet.*	
No. 112 and 128	8¾	+0.194	J. C. Cammack.
No. 128 and 137	5½	−0.017	Do.
No. 137 and 140	1½	—0.195	Do.
No. 140 and 150	5½	—0.042	Do.
No. 150 and 162	15	—0.144	J. C. Cammack and M. Greenwood.
No. 162 and 171	5	—0.043	M. Greenwood.
No. 171 and 179	4	—0.042	Do.
No. 179 and 184	2½	—0.064	Do.
No. 184 and 188	2	—0.077	Do.
No. 188 and 197	5	—0.100	Do.
No. 197 and 207	4½	—0.007	Do.
No. 207 and 211	4½	—0.084	Do.
No. 211 and 225	7½	—0.039	Do.
No. 38 and 37	5	+0.071	Do.
No. 37 and 36	3½	+0.051	Do.
No. 36 and 35	6	—0.076	Do.
No. 35 and 34	9	+0.064	Do.
No 34 and 33	5	—0.078	Do.
No. 33 and 32	6½	+0.043	Do.
No. 31 and 29	1¾	—0.074	C. N. Roberts.
No. 29 and 28	1	+0.090	Do.
No. 28 and 27	3¾	—0.030	Do.
No. 27 and 26	4¾	—0.116	Do.
No. 26 and 25	7	—0.014	Do.
No. 25 and 24	5	+0.023	Do.
No. 24 and 23	5¾	+0.138	Do.
No. 23 and 22	2¾	—0.163	Do.
No. 22 and 21	6½	−0.186	Do.
No. 21 and 20	4¾	+0.010	Do.
No 20 and 19	3¾	—0.062	Do.
No. 19 and 17	6¾	+0.030	Do.

The sum of these discrepancies is —0.869 feet for a distance of 159 miles.

Discrepancies between right and left bank ordinary levels.

Locality where compared.	Distance.	Discrepancy.
	Miles.	*Feet.*
Ajax Bar	7	0. 221
Hays' Landing	8½	0. 018
Wilton Landing	6	0. 109
Chotard Landing	11	0. 167
Henderson Landing	4½	0. 139
Omega Landing	6	0. 130
Halpino Landing	6	0. 111
Young's Point Landing	10½	0. 219
Delta, La	4½	0. 100
Near Big Bayou	4½	0. 100
Mount Pleasant Landing	12	0. 028
Head of Profit Island	2½	0. 278
Grossman's Landing	8	0. 189
Belmont Landing	8	0. 130
Arlington Landing	8½	0. 004
Duncan's Point	5	0. 113
Hollywood Landing	8½	0. 100
Plaquemine	7½	0. 122
Forlorn Hope	4½	0. 036
Point Pleasant	4	0. 014
Ophelia Landing	2½	0. 064
Belle Grove Landing	7	0. 092
Claiborn Island	5	0. 005
Ashland Landing	4	0. 194
Donaldsonville	8	0. 046

HIGH-WATER MARKS.

Lake Providence	Well-defined mark on tree opposite Lake Providence, La	1882	114. 98
Bass Landing	Nail in large oak tree	1882	111. 53
Do	do	1880	109. 49
Island No. 97	Well defined mark on Mr. Zach. Leatherman's house, about one mile below Arcadia Landing.	1882	110. 45
Milliken's Bend	On steps of Morancy's house, back of levee	1882	102. 25
Cabin Teele	Mark cut on corner of gin-house in front of levee	1882	105. 05
Young's Point	On steps of dwelling three miles below Young's Point Landing	1882	99. 62
Port Hickey	On United States gauge	1882	47. 60
Plaquemine	Mark on tree two miles above Plaquemine	1882	39. 60
Forlorn Hope	Nail in cottonwood tree at landing	1882	39. 00
Do	do	1880	35. 40
Saint Gabriel's Church		1882	37. 65
Bayou Goula	Well-defined mark on warehouse	1882	37. 35
Ashland Landing	Mark on warehouse established by Gen. J. Thompson	1874	36. 12
Donaldsonville	Marks cut on northwest corner of market-house by Gen. Jeff. Thompson.	1862	35. 21
Do		1869	33. 73
Do		1874	35. 18

Table showing surface slope of river as determined by this survey.

	Distance.	Slope per mile.	Vicksburg gauge-reading.	Rising or falling.
	Miles.	*Feet.*		
Lake Providence to head of Island 95	6. 7	0. 70	11. 50	Falling.
Head of Island 95 to Hays' Landing	3. 5	0. 49	9. 2	Stationary.
Hays' Landing to Wilton	6. 8	0. 40	8. 9	Do.
Wilton to Chotard	10. 8	0. 54	9. 0	Falling.
Chotard to Omega	8. 3	0. 26	8. 8	Stationary.
Omega to Halpino Landing	7. 0	0. 55	11. 2	Rising.
Halpino to Nebraska Landing	4. 5	0. 36	13. 5	Do.
Nebraska Landing to King's Point	5	0. 19	12. 6	Falling.
King's Point to head of Warrenton T. H	5. 5	0. 16	11. 2	Do.
Bayou Sara to Kelson Landing	12. 8	0. 14	*15. 2	Rising.
Kelson Landing to Lobdell's Landing	12. 5	0. 13	*14. 5	Stationary.
Lobdell's Landing to Baton Rouge	10	0. 12	*18. 7	Rising.
Baton Rouge to Manchac	10	0. 12	*24. 1	Do.
Manchac to Forlorn Hope	14	0. 12	*27. 5	Do.
Forlorn Hope to Bayou Goula	7. 6	0. 14	*26. 6	Stationary.
Bayou Goula to Donaldsonville	19. 5	0. 12	*30. 4	Rising.

*Baton Rouge gauge.

The quantity and quality of the work accomplished is due in a great measure to the energy and efficiency of my assistants, to whom I desire to express my thanks for the cheerful and faithful manner in which they performed their duties.

Very respectfully, your obedient servant,

C. M. WINCHELL,
United States Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

3.—REPORT OF ASSISTANT ENGINEER L. L. WHEELER, WARRENTON TO NATCHEZ.

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., July 5, 1883.

SIR: I have the honor to submit the following report upon the operations of the party in my charge during the season of 1882-'83.

The work assigned to the party was to make a topographical and hydrographical survey of that portion of the Mississippi River lying between Warrenton and Natchez, Miss. The survey was to include both banks for at least three-quarters of a mile on each side, and in all cases to include the levees. It was also to include old cut-off lakes, sloughs, bayous, bluff-lines, and other topographical features within a distance of ten miles of the river.

The party left Saint Louis the evening of October 16, 1882, and went on board the quarter-boats Illinois and Kentucky, at Cairo, the following day. The boats were taken in tow by the steamer Oakland, October 21, and arrived at Vicksburg October 28. Two days were spent in putting supplies, coal, &c., on board at Vicksburg, and the boats were towed down to Warrenton October 31.

Assistant Engineer E. E. Haskell was taken sick soon after the party took the field and was obliged to return to Saint Louis. Assistant Engineer H. B. Wood and Alex. E. Kastl were detailed for making special surveys near Arkansas City, and joined the main party about the middle of November. Assistant Engineer O. W. Ferguson and Recorder E. K. Woodward, jr., joined the party December 4. Samuel Fitzhugh was promoted from rodman to recorder January 1, 1883. The party, as finally organized, consisted of Assistant Engineers A. N. Darrow, O. W. Ferguson, H. B. Wood, A. H. Weber, J. W. Dorst, O. A. Orrman, A. E. Kastl, and A. N. Milner, and Recorders Fred. Morley, E. K. Woodward, jr., and Samuel Fitzhugh, with the necessary complement of men.

The field-work commenced November 1 on the triangle side "Last-Big Bayou," about seven miles below Vicksburg, and continued until February 22, 1883, when the work was completed to Natchez.

The following day instruments, charts, note-books, &c., were packed and sent by express to Saint Louis, and the party disbanded, the assistants returning to the office.

The party was therefore engaged in field-work 114 days, 16 of which were Sundays, one an observed holiday, and on 14 the weather was such that no field-work could be done. Field-work was therefore done on 83 days, on many of which, however, only part of the day was suitable for work.

The length of main river surveyed was 93 miles, embracing 217.2 square miles of topography, and 63.3 square miles of hydrography, or a total area of 280.5 square miles surveyed.

The survey was based upon a system of triangulation and a line of precise levels executed by the United States Coast and Geodetic Survey, the results of which were furnished from that office. The survey was made in the following manner:

1st. A line of levels was run on each bank, which determined the elevations of triangulation stations, sounding-stakes, stadia-stakes, stone-line bench-marks, water-gauges, high-water marks, water surfaces, &c. The levels on the right bank were checked by the precise levels, and those on the left bank by reciprocal leveling across the river. The two lines also mutually checked each other by frequent determinations of water surfaces on opposite sides of the river. All elevations were referred to the Memphis datum plane, which is a plane 225 feet below the reading 34.16 on the Memphis gauge. The leveling was performed by Assistants Dorst and Kastl.

2d. A stadia line was run on each bank, checking frequently as to azimuth and distance upon triangulation stations and intersections on distant signals, and as to elevations upon the line of levels run on each bank.

The principal topographical features along the river bank, including landings, gauges, lights, sounding-stations, &c., were located when the shore line was run. The topography back from the river was taken by lines run back for that purpose. Where the country was wooded lines were cut back from the river three-fourths of a mile in such a direction as would best determine the topography. The locating of levees, lakes, bluffs, bayous, &c., when beyond the limit of topography, was done by stadia lines connecting with the main lines. The topographical work was done by Assistants Darrow, Ferguson, Weber, Milner, and Recorder Woodward.

3d. The hydrography consisted of lines of soundings taken normal to the stream every 400 meters, and a line of soundings taken longitudinal to the stream. The soundings were taken with a 22-pound tallowed lead, about every third sounding being located by sextant angles between signals on the banks. A sounding line of Italian hemp was first used, but was discarded and a cotton line used instead.

Assistant Wood and Recorder Morley performed the hydrographical work, and also materially aided in the other work of the survey.

4th. The points located by the topographical parties were plotted on protractor sheets to the scale 1:10000, the sketching, contours, &c., being put in by the observers when field-work could not be done. The plotting was done by Assistant Orrman.

5th. All notes were reduced in the field, and all note-books indexed.

6th. The points of the survey were marked on the ground by the usual lines of marking-stones, the positions and elevations of which were determined, and descriptions of which were made in a book kept for that purpose.

My thanks are due to the assistants and recorders for their hearty co-operation and interest in the work. Assistants Darrow, Ferguson, and Wood gave me valuable assistance aside from their regular duties, and deserve special mention for the interest shown in the general progress of the party.

Very respectfully, your obedient servant,

L. L. WHEELER,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

4.—REPORT OF ASSISTANT ENGINEER H. B. WOOD, UPON RESURVEYS IN FRONT OF CREVASSES.

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, September 15, 1883.

SIR: I have the honor of submitting to you the following report on hydrographic work above Arkansas City, completed during the months of October and November, 1882.

The special object being to ascertain the effect of large breaks in levees upon the river bed during the great spring flood of 1882, four reaches in the immediate vicinity of said breaks were selected for hydrographic observations, all of which were located in that portion of the river surveyed by the party in charge of Mr. J. A. Ockerson, assistant engineer, during the winter season of 1881–82, just before the flood. The first reach extended from Malone's Landing, near the foot of Island No. 66, to Australia; the second, from Riverton to the head of Ozark Island; the third, from Bolivar to Cypress Creek; and the last, from Mound Place to Arkansas City.

The party consisted of two assistant engineers, pilot, steam engineer, fireman, cook, leadsman, and two rodmen, and was provided with the tug Eva, of Helena, two skiffs, and camping outfit.

To re-sound the sections as located by the previous party required that the stone lines should be found, and where no Δ stations or other landmarks of prominence served to identify the other sections, a stadia line was run, and the positions of former sections marked. Accordingly, with some few exceptions, the re-sounded sections were identical with those previously established.

The water surface was connected at frequent intervals with established benches referred to the Memphis datum, and a constant gauge record kept during the progress of the work.

In the first reach, from Malone's Landing, thirty-two sections were re-sounded, covering a distance of about sixteen miles. These cross-sections have been plotted, together with the corresponding ones of the previous year, and their areas approximately measured with the planimeter, the results being tabulated herewith. A very small amount of filling-in below the breaks occurred here. By the annexed table of compared areas of cross-sections, it will be seen that an average fill has taken place, making each section about 2,200 square feet less in area than before the flood, not counting sections that were above or below their former position.

In the second reach, from Riverton, seventeen sections were re-sounded, covering about nine miles. Here each section averaged about 11,000 square feet less in area than formerly.

In the third reach, from Bolivar, where eighteen sections were re-sounded in a distance of ten miles, each section averaged 8,400 square feet less in area than when sounded the previous year.

In the last reach, from Mound Place, where nine sections were re-sounded in a distance of four miles, each section averaged 23,800 square feet less in area than before the flood.

* * * * * * *

The following approximate crevasse discharges for the several reaches were measured by Assistant Engineer J. B. Johnson:

	Cubic feet per second.
First reach, Lake Charles and Pushmataha Breaks	15,000
Second reach, Riverton Break	107,400
Third reach, Bolivar Breaks	128,250
Fourth reach, Mound Place Break	20,660

The above survey occupied from October 10, 1882, to November 10, 1882, during which time seventy-six sections were resounded, covering forty miles of the total distance of one hundred and forty-five miles to Arkansas City. At the conclusion of the work, the party proceeded to Vicksburg, and joined the party in charge of Mr. L. L. Wheeler, Assistant Engineer, then located at Moore's Landing, according to your orders.

Very respectfully, your obedient servant.

HENRY B. WOOD,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

Table showing approximate areas of cross-sections below a common water-level both before and after the flood of 1882.

FROM MALONE'S LANDING TO AUSTRALIA.

Section.	Area before flood.	Area after flood.	Difference.	Remarks.
	Square feet.	*Square feet.*	*Square feet.*	
Stone line No. 38	62,550	97,550	....	Cut out by chute 66.
16	84,200	84,100	− 100	
17	77,100	68,100	− 9,000	
18	81,000	64,000	−17,000	
19	71,550	69,100	− 2,450	
20	67,150	60,900	− 6,250	
Stone line No. 39	60,000	78,400	+18,400	
25	66,800	61,800	− 5,000	
26	56,450	63,250	+ 6,800	
27	52,000	59,550	....	410^m below old sect.
28	61,550	66,500	+ 4,950	
29	48,700	38,500	−10,200	
30	52,750	57,000	+ 4,250	
31	45,200	41,900	− 3,300	
32	49,100	44,400	− 4,700	
29 (chute 68)	14,850	13,850	− 1,000	
Ft. chute	15,250	19,000	+ 3,750	
33	54,950	49,100	− 5,850	
34	84,400	77,050	− 7,350	
35	78,050	75,550	− 2,500	
36	71,500	78,650	+ 7,150	
37	74,850	72,850	− 2,000	
38	61,650	58,550	− 3,100	
39	61,600	55,550	− 6,050	
40	62,350	56,800	− 5,550	
41	61,000	51,000	−10,000	
42	49,100	50,000	+ 900	
△ Id. 69	55,400	64,000	....	Below old sect.
44	66,000	78,000	....	Do.

Table showing approximate areas of cross-sections below a common water-level both before and after the flood of 1882—Continued.

FROM RIVERTON TO HEAD OF OZARK ISLAND.

Section.	Area before flood.	Area after flood.	Difference.	Remarks.
	Square feet.	*Square feet.*	*Square feet.*	
103	65, 300	69, 800	+ 4, 500	
104	74, 050	64, 850	− 9, 200	
106	70, 550	43, 100	−27, 450	
107	87, 100	66, 400	−20, 700	
△ Ark River	109, 400	91, 900	−17, 500	
109	71, 300	90, 100	+18, 800	
110	50, 000	63, 150	+13, 150	
111	92, 000	65, 600	−26, 400	
112	92, 550	74, 150	−18, 400	
113	68, 200	65, 750	− 2, 450	
113 A	75, 350	57, 400	− 7, 950	
114	65, 250	56, 450	− 8, 800	
115	92, 200	69, 100	−23, 100	
Angle 14 to Angle 22	12, 600	34, 600	....	In pocket below old sect.
Angle 22 to ⊙ L 118	109, 000	79, 700	−29, 300	
△ Crow Pt	169, 050	158, 450	−10, 600	

FROM BOLIVAR TO CYPRESS CREEK.

Section.	Area before flood.	Area after flood.	Difference.	Remarks.
137	52, 500	46, 800	....	Below old sect.
Old River	12, 150	11, 000	− 1, 150	
138	82, 650	48, 800	....	300ᵐ below.
139	75, 350	51, 850	−23, 500	
140	92, 150	63, 000	−29, 150	
141	79, 800	70, 150	− 9, 650	
142	74, 250	68, 100	− 6, 150	
142 A	70, 100	50, 750	−10, 350	
⊙ L 148	58, 200	62, 100	+ 3, 900	Midstream.
△ Jersey Pt	57, 950	45, 650	−12, 300	
△ T. H	4, 100	2, 700	− 1, 400	Old River, Catfish T. H.
A	35, 250	32, 900	− 2, 350	
B	53, 550	45, 650	− 7, 900	
C	87, 650	60, 400	−27, 250	
D	66, 700	56, 000	−10, 700	
Stone line No. 58	75, 950	73. 600	− 2, 350	
F	81, 850	87, 100	+ 5, 250	
△ Good Luck	62, 550	68, 500	+ 5, 950	
151	68, 450	64, 250	− 4, 200	
153	72, 500	53, 900	−18, 600	

FROM MOUND PLACE TO ARKANSAS CITY.

Section.	Area before flood.	Area after flood.	Difference.	Remarks.
173	60, 600	71, 200	+10, 600	
174	94, 500	66, 150	−28, 350	
176	100, 700	67, 150	−33, 550	
177	106, 700	56, 550	−50, 150	
178	79, 600	64, 550	....	200ᵐ above old sect.
179	102, 000	88, 800	−13, 200	
180	122, 350	90, 000	−32, 350	
Stone line No. 63	103, 550	83, 600	−19, 950	

APPENDIX B.

REPORT OF ASSISTANT ENGINEER E. S. DAVIS UPON THE FIELD-WORK AND RESULTS OF TRANSALLUVIAL LEVELS.

SAINT LOUIS, MO., *June* 21, 1883.

SIR: I have the honor to submit the following report on the work of trans-alluvial leveling.

The scheme for this work contemplated nine sections, located at the following-named places, all of which have been run, except No. 3:

1. From the Mississippi River, at Island No. 13, east and west to land above overflow.
2. From the first Chickasaw Bluff west to land above overflow.
3. From Memphis west to uplands beyond the Saint Francis River, on line of Memphis and Little Rock Railroad.
4. From Helena east to upland.
5. Up Cypress Creek to land above overflow.
6. From Grand Lake to Bayou Maçon Hills; up Bayou Maçon Hills across the cut-off to land above overflow.
7. From Lake Providence east to Yazoo City.
8. From Grand Gulf west to high land of Sicily Island.
9. From Fort Adams west to Avoyelles Prairie; thence two branches, one across Bayou Bœuf, and one across Red River.

The location of No. 8 was changed from Grand Gulf to Saint Joseph.

The line contemplated from Memphis has each season been omitted, with the expectation of running it after work on other sections had been made impracticable by the presence of water in the swamps. It has happened, however, that this line has been submerged when work on other lines had been abandoned, and it yet remains to be done.

The work has occupied three seasons. The following table gives the amount done each season; also the daily average rate of progress. The time given each season includes the time from leaving Saint Louis to date of disbanding the party:

Season.	Distance.	Time.	Average daily rate.
	Miles.	*Days.*	*Miles.*
1880-'81	62	150	.41
1881-'82	52	104	.50
1882-'83	164	174	.97

About 20 per cent. of the time spent in the field has been occupied in traveling from Saint Louis and between lines.

Over each line levels in duplicate and a traverse have been run. All streams crossed have been gauged roughly; elevations of high-water marks have been taken where they could be found. An azimuth has been observed at the inland end of each line except No. 5.

During the first season (1880-'81), Mr. Hunter Stewart assisted me, he running the traverse and I the levels. A transit and stadia were used in running the traverse, the stadia being used to measure all distances. An ordinary level and target-rod were used in running the levels.

During the first part of this season the levels were checked by running between benches a second time. During the latter part of the season the levels and check levels were run at the same time, the following method being employed: After the rod had been read in the usual position, it was inverted and held on the same point as before, and another set of readings taken. This method of checking levels will be discussed later. During the second and third seasons a combined level and transit was used.

The combination was made by fastening the essential parts of a Stackpole level to the limb of a Würdemann transit.

The device for making the combination is very simple and inexpensive, as shown by the following sketch:

Fig. 1.

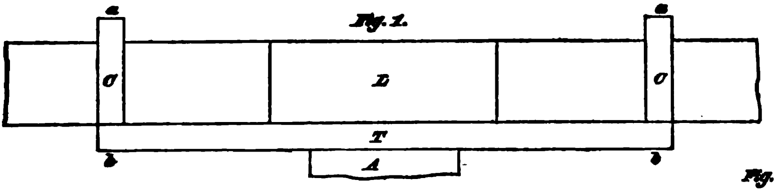


Fig. 3.

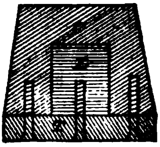


Fig. 2.

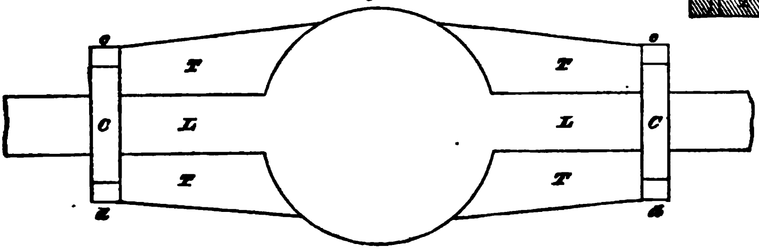


Fig. 1 is a vertical projection of a part of the instrument.

L is the bar of the level.

T is the bar of the transit.

A is the transit axis.

C and C are the collars used to hold the two instruments together.

Fig. 2 is a horizontal projection of the same parts.

Fig. 3 is a right section through the collars and shows how the parts are fastened together. When a transit was needed for azimuth observations, the screws shown in Fig. 3 were taken out, the collars and level bar removed, and the transit wyes fastened on the transit bar by the same screws. It took only a few minutes to make this change.

By the use of the combined instrument one observer was enabled to run the levels, check levels, and traverse at the same time.

As a level the combination worked admirably, and the results of azimuth observations indicate that it worked well as a transit, although the vernier plate was a little below the plane of the limb, caused by the weight of the level attachment.

When the vernier plate was brought up to the plane of the limb the spindle had a little play in its socket, which was not desirable in the level; therefore the spindle was allowed to sink far enough into its socket to prevent the play.

There was no means of causing the telescope to revolve in a vertical plane, at the same time keeping the plane of the limb horizontal. However, the necessity for reading angles with the telescope inclined did not occur very often; when it was necessary, it was accomplished by setting the instrument up so that one of the foot or supporting screws would be in the plane in which it was desirable to revolve the telescope, then the foot screw was used for inclining the telescope. By exercising due care only a small error is introduced in this way.

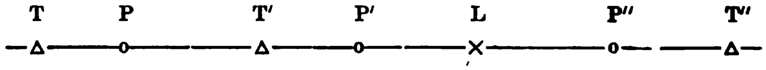
The telescope used contained three horizontal cross-wires, all of which were read when practicable. It frequently happened, however, that one or the other of the outside wires could not be read. The middle wire and one of the outside wires were always read. Distance tables were computed for all of the intervals, so that distance from the instrument to the rod could always be determined. Self-reading metric rods were used.

Angle or transit stations were taken as far apart as the rods could be seen. The rods used on these stations were straight poles covered with strips of black and white cloth.

The distance between transit stations was obtained by taking the sum of the distances measured between them.

The turning points and level stations between transit stations were as nearly on line as practicable.

The following sketch and explanation will show the method:



T, T′, and T″ are three consecutive transit stations.

Suppose the instrument to be at T; then T″ is located as to direction by the angles read at T′. The turning point P′ is put on line T′ T″; the instrument is then moved to L and set up on line by ranging in with T′ and P′ and the turning point P″ put on line L T″. The rods at P′ and P″ are read, the instrument is moved to T″, and the rod at P″ read; then the distances T′ P′, P′ L, L P″, and P″ T″ are known and the distance T′ T″ is equal to their sum.

For the levels two rods were used, so that at every instrument station the back and fore sights were taken on different rods. Referring to sketch above, when instrument is at T′ one rod is at P and the other at P′; after completing readings, instrument is moved to L, the rod held at P for last setting is now carried to P″, and so on. By having two rods very little time is lost in waiting for rodmen. By the time the instrument is set up at L the rodman has had time to walk from P to P″ and is ready to be put on line.

LEVELS AND CHECKING.

The instrument being set up between two turning points, the rods were first held with their zeros on the points, and the readings recorded. Then the rods were inverted and held on the same points as before and another set of readings recorded in the same book and immediately below the first set.

The line run with inverted rods serves as a line of check levels. Wooden pegs were used for turning points, and were driven down nearly flush with the surface of the ground, so that elevations of turning points are practically elevations of the ground.

A copy of a page of my note-book is given to illustrate the method of keeping the notes and making the computations.

An examination of the notes will show that the method employed gives two independent lines of levels, the readings on any one rod for the two positions being entirely different, except when the middle wire reads at the middle of the rod.

Station.	S.	O.	B. S.	E.	H. of I.	F. S.	Int.	Dist.	O.	Vernier I.	Vernier II.	Remarks.
......	B	R P 8	1.389	36.436	37.693	1.556						
	F	99	1.257	36.262	....	1.431						
			1.128	....	....	1.311						
			.261	....	....	.243						
			2.044	†36.436	†34.260	1.877	.261	25.9				
			2.176	†36.250	....	1.999	.244	24.3				
			2.305	....	....	2.120						
			.261	......	....	.243				° ′ ″	° ′ ″	
40	B	99	1.748	36.262	37.762	1.870	....	......	39	14 19 00	194 18 00	Large timber and very thick underbrush.
	F	100	1.500	36.144	....	1.618	......	......	41	208 32 00	28 32 00	
			1.258	....	....	1.370	......	......	....	83 44 00	263 44 00	
			.490	....	....	.500	......	......	...	277 56 00	97 56 00	
			1.684	†36.259	†34.328	1.561	.4895	48.4	499	83 30 00		
			1.931	†86.142	....	1.814	.5005	49.4	100	277 46 00		
			2.173	....	....	2.060						
			.489	....	....	.501						
......	B	100	1.740	36.144	37.517	1.706						
	F	101	1.873	36.198	....	1.319						
			1.018	....	....	....						
			.722	....	....	.387						
			1.693	†36.142	†34.083	1.728	.722	71.1				
			2.059	†36.197	....	2.114	.3865	75.2				
			2.415	....	....	....						
			.722	....	....	.886						

The figures in columns 1, 2, 3, 4, 7, 10, 11, 12 and 13 are the original notes, except the intervals written under each set of readings in columns 4 and 7; the other figures are reductions.

NOTES AND REDUCTIONS.

An inspection of the notes will show the manner of keeping the field records.

Only the mid-wire readings are used in reducing the heights of instrument and elevations, the reductions for rod inverted being marked (†).

Rod in first position, back sights are plus.

Rod in first position, fore sights are minus.

Rod inverted, back sights are minus.

Rod inverted, fore sights are plus.

The readings of the outside wires are used for determining distances.

The intervals are taken out and placed beneath the sets of readings to which they belong. In the eighth column the mean intervals are placed opposite readings for inverted rod, the back-sight interval being placed first. In the ninth column the distances are placed opposite the proper interval.

Of course objections may be raised to this method of checking levels.

It might be said that any lack of adjustment of the instrument and local disturbances would affect both lines alike, or in the same direction, and it is granted that such is the case. However, errors arising from these sources would not be likely to influence the results beyond the errors of discrepancy allowable in this class of work, especially when care is taken to keep the instrument in good adjustment, and to keep back and fore sights equal. I feel perfectly confident in saying that this mode of checking levels would detect any error caused by a blunder in reading the rod. Again, it might be said that the observer, knowing the length of the rod, would know what the second set of readings should be, the sum of the readings of any wire in the two positions of the rod being equal to the length of the rod, and that the second set of readings might be vitiated by any error that might have been made in the first set.

I think, however, that an error from this source would hardly occur, unless the observer intentionally computed what the second set of readings should be, and recorded them as observed readings.

It will of course be admitted that this method saves a great deal of time, the only additional time required for checking a line of levels being that necessary to take a second set of readings at each instrument station.

There is still another advantage of the system, to which I desire to call attention. There is sufficient data given when all the wires are read, to enable one to correct any error that might have been made in any reading.

MAPS.

The traverse of line No. 1 was plotted on Manilla paper, scale 1:10000; the profile was plotted on cross-section paper, scale 1:60, and the whole transferred to tracing cloth; the traverse and profile of lines 2 and 4 were plotted on protractor sheets, horizontal scale 1:10000, vertical scale 1:60, and the whole transferred to tracing cloth. The traverse of lines 5, 6, 7, 8, and 9 was plotted on protractor sheets, scale 1:10000, and their profiles plotted on tracing cloth, scale 1:60. The profiles of surface of high water of 1882 have been plotted on lines 2, 5, 6, 7, 8, and 9; the profile of high water of 1867 has been plotted on line No. 4. All the lines, traverse and profile, have been plotted on paper; horizontal scale, 1:100000; vertical scale, 1:120.

All the reduced maps, except that of line No. 1, show the profile of surface of high water of 1882. The map of line 1 shows the surface of high water of 1882 at several places, obtained from the answers to a set of questions sent to persons residing along the section.

The high-water profile for 1882, plotted on line No. 4, was reduced from the high-water profile of 1867, plotted on the large-scale map by taking the difference of the high waters of 1867 and 1882 at Helena, and making the profiles parallel. The high-water profiles for the other lines were plotted from high-water marks taken while running the sections.

The above-named maps and profiles are herewith respectfully submitted as a part of this report.

The time occupied in completing this work has been much greater than was at first anticipated. However, the nature of the country through which the sections were run, taken in connection with the fact that the first two seasons were very unfavorable, will account, in some measure, for the slow rate of progress.

The country through which the sections were run is mainly uninhabited, and is heavily timbered. This made a great deal of clearing of lines necessary, which greatly retarded the progress of the work.

The almost entire absence of roads made the transportation of camp equipage a serious difficulty even when the swamps were dry; when the swamps were wet the difficulty was very much increased; several bridges and rafts have been built in order to cross streams. It has been necessary on several occasions to abandon all camp equipage except what could be carried by my men, on account of the impossibility of getting pack animals through the swamps.

Very little time has been lost on account of sickness; in fact, the health of my party has been better than could reasonably have been expected.

Very respectfully, your obedient servant,

E. S. Davis,
United States Assistant Engineer.

First Lieut. Smith S. Leach,
Secretary Mississippi River Commission.

APPENDIX F.

REPORTS UPON, AND RESULTS OF, RIVER GAUGINGS AT VARIOUS POINTS ON THE MISSISSIPPI AND OHIO RIVERS.

1.—AT CLAYTON, IOWA, AND PADUCAH, KY.—W. G. PRICE, ASSISTANT IN CHARGE.

CARROLLTON, LA., *May* 10, 1880.

LIEUTENANT: In accordance with your order of April 26, 1883, I have the honor to submit the following report on the work of observing discharge at Clayton, Iowa, and Paducah, Ky., and on methods of measuring the discharge of rivers.

OBSERVATIONS AT CLAYTON, IOWA.

In accordance with orders received from you, I arrived at Clayton, Iowa, on October 12, 1880, and proceeded to make a reconnaissance of the Mississippi River in the vicinity of the mouth of the Wisconsin, for the purpose of finding the most favorable location for a discharge section. There was some delay in making the selection, but the party got well started by the 25th of October, and the work was carried on without serious interruption till October 25, 1881. Until the breaking up of the ice on March 29, 1881, all the velocity observations were measured with the meter. After the ice stopped running, April 12, 1880, observations were taken with rod-floats, used in connection with the plant.

During the entire season 222 velocity observations were made, of which 85 were with the meter and 137 with rod-floats. Besides the regular velocity observations for discharge, there were taken 36 sets of vertical observations.

The balance of the work comprised:

53 sets slope observations.
28 sets longitudinal soundings.
40 sets sediment observations.
10 sets dredgings.

The results of this work were published in the Report of the Commission for 1882, page 133.

OBSERVATIONS AT PADUCAH, KY.

Arrived at Paducah November 29, 1881, and made observations of discharge from this time till November 26, 1882. During this time 215 discharges were measured, of which 27 were with rod-floats and 188 with the meter and plant. In addition to these velocity observations there were 208 verticals taken. A few of the observations were taken partly with rods and partly with the meter, but this was only an occasional occurrence.

The results of this work, as computed in the office of the commission, are appended to this report.

METHODS OF MEASURING THE DISCHARGE OF RIVERS.

Method with double floats.

I think these floats do not give the mid-depth velocity, owing to the effect the current has on the upper float and connecting wire. The upper float is also affected by the wind. Observers are supposed to use a very fine wire to connect the floats, but as this causes much trouble by breaking, a strong string is usually put in, and this catches too much water. For this reason the measurement would be too great except where there is a strong up-stream wind, when it might be too small. Measurements of vertical curves of velocity with double floats in an up-stream wind show a much greater decrease of velocity near the surface than the same measurements with the current meter.

The mid-depth velocity is not always a mean velocity. I think it varies with different sections and with different stages of water, being from 1 to 4 per cent. greater than the mean. At Paducah, Ky., during the year 1882, it was about 4 per cent. most of the time, being a little less at low water. At Carrollton during this year's observations it has been 4 per cent.

For timing floats a stop-watch is used, and I think they cannot be depended upon unless in the hands of a careful engineer who has the mechanical skill to keep them in order.

There is no check on any of the observers, one of whom being a careless man will spoil the accuracy of the work. The shore observers may work with their instruments out of adjustment; they may miss the float but, give the signal as though all was right; or the floats, to save labor, may not be adjusted to mid-depth, and the chief of the party may not know it.

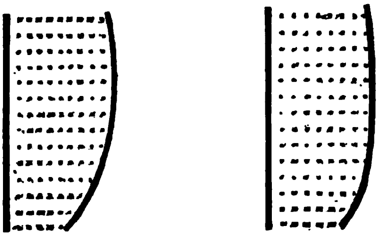
Method with rod-floats.

When these floats are observed from the shore, as with double floats, there is no check on any one of the observers. Careless observers will let the float project too much out of water so that it is affected by the wind. It is impossible to run floats nearer than one or two feet of the bottom, and where the sand waves are three feet high they are liable to be over three feet from the bottom most of the time. In deep places they often do not reach to mid-depth.

As the vertical curve of velocity varies very much with different sections, and also at different points on the same section, it is impossible to make a formula which will reduce the observed velocity to a true mean. For this reason when the floats do not reach nearly to the bottom they may not be as accurate as the double floats. At Carrollton, La., where the water is over 100 feet deep, it would not be easy to run floats reaching to mid-depth, and as the velocity at three-fourths of the depth is frequently found to be as great as it is at mid-depth or the surface, the observed velocity of a float reduced by Francis' formula would be far from correct.

At Paducah, Ky., the discharge was measured once a week during a part of the year by both rod-floats and the meter. The floats were run at the same stations and at the same time that the meter was running. The apparatus for running the floats was attached to the stern of the catamaran, which was anchored. The floats were timed by a good stop-watch, which was kept in good order, and it was stopped and started automatically by electricity. During the time these measurements were taken the river fell from about a medium stage to low water. At first the rod-float discharges were the greatest, but when the river had fallen much lower they were less than those taken with the meter. When the rod-float discharges were the greatest the vertical curves of velocity taken with the meter were like Fig. 1, and when they were less they were like Fig. 2.

Fig. 1. *Surface.* *Fig.* 2.



Bottom.

This showed that the observed velocity of the floats had not been reduced enough at first, and afterwards too much, though the same formula (Francis') was used all the time.

The method of running rod-floats from an anchorage with an automatic electrical apparatus for timing them is far more accurate than that with observers on shore, and the only part not checked is the reading of the stop-watch, and this should be tested at least twice a day by comparison with an ordinary watch.

Method with current meter.

In this method the man who has charge of the field-work can see that every part is done correctly. An ordinary watch can be used for timing the meter, so there is no error from this source.

It has been supposed that the meter measurements are too great, as it takes in all the oscillations of the current. Observations at Paducah, Ky., a report of which was forwarded on October 10, 1882, show that the horizontal oscillations of the current are so small they hardly increase the registrations at all, while another observation at Carrollton, La., the result of which was given in my report of April 20, 1883, shows that the vertical oscillations do not increase the measurements by the meter.

If the meter is a good machine and in the hands of a careful observer, I think it cannot fail to give correct results, while the methods with floats have been in use for a long time, and have been carried to as great perfection as possible, and yet do not give perfect results.

The method with the meter has been greatly improved during the last three years, and it was not till this year, after I had made a good many changes, that I became satisfied with the apparatus in use.

Experience shows that the only meter which will work in water which carries leaves and grass, is one with a wheel which turns like the Ellis. But the Ellis meter was not constructed with a knowledge of the difficulties it would have to contend with in the Mississippi. Owing to the particles of sand in the water the contact would not always work, and the bearings of the wheel were ruined in a short time. Small pieces of drift striking the light wheel bent or broke it, and sometimes carried it away. Repairs and new ratings were required very often. The apparatus for using it was not perfect. The insulated wire would break; the electric connection would fail, and it would bè almost impossible to find where the trouble was. But the apparatus has been greatly improved, so that it is now no trouble for an ordinary boatman to manage it. A meter has been constructed which overcomes the old difficulties, and which requires no more attention than simply to be oiled occasionally.

The meter at Carrollton, La., has not been taken apart, or received any attention except to oil it, in nearly three months, and it cannot be seen that it is worn in the least, or is not just as perfect a machine as when it was constructed. The contact has never failed, and the register has never stopped except when the insulated wire was worn out.

The ratings of this meter do not vary more than one-tenth of 1 per cent., and I think that this variation is the fault of the observers. It is my experience that it requires a great change in the amount of friction with which the wheel turns, to make 1 per cent. variation in the rating.

Comparison of methods.

On the Lower Mississippi, at high water, a float will pass over the 200-foot section in less than 30 seconds. If 26 floats are run (and I believe that is about the usual number), the velocity will be measured just 13 minutes during each survey, which would require about four hours. Now, if the meter was used to take a discharge, in four hours it would have been measuring all the pulsations of the current during about 200 minutes.

A float passing over the 200-foot section in 30 seconds measures the velocity of the water only in its immediate vicinity, while the meter running only 30 seconds would measure the velocity of a line running through a 200-foot block of water.

Suppose that the observed velocity of a float could always be reduced to a true mean, and that the meter always measures the velocity correctly, it would require more than 20 floats to equal the accuracy of a 10-minute run of the meter; and at two stations at Carrollton it is necessary to run the meter 20 minutes in order to get an average velocity.

Cost of different methods per month for large rivers:

Method with double-floats or rod-floats:

One assistant engineer	$130
One recorder	90
Two leadsmen, at $55	110
Four boatmen, at $45	180
Total	510

Method with current meter:

One assistant engineer	$130
One engineer of launch	90
One steersman	55
Two boatmen, at $45	90
One steam launch	100
Total	465

For small rivers where a wire anchorage can be used:

Method with double-floats:

One assistant engineer	$130
One recorder	90
One leadsman	55
Two boatmen, at $45	90
Total	365

Method with rod-floats or the meter:

One assistant engineer	$ 130
Two boatmen, at $45	90
Total	220

The above is the force required to measure the discharge. If the work is to be computed in the field, one recorder will be required in addition to the force given for each method, though the work could be partly computed without him. Data taken with the meter are much the easiest to compute.

CONCLUSION.

I think the method with the current meter is the most accurate and reliable, and for large rivers it is the cheapest. For small rivers the method with rod-floats is nearly as cheap as the method with the meter.

For small rivers where a wire anchorage can be used, the method with rod-floats is much more accurate than the method with double-floats observed from the shore; but in a large, deep river I doubt if the rod-floats are as accurate as the double-floats.

I recommend the following method for measuring the discharge of rivers:

Location of section.

The section should be located in a straight reach if possible and not very near a tributary.

The section at Paducah, Ky., was located just below the mouth of the Tennessee, and the Tennessee water being warmest, and therefore lightest, spread over the Ohio water; and as the Tennessee current was much the slowest, there was a slow surface current and a swift undercurrent; and these currents were not parallel, but ran at an angle of about 20°; this caused a great deal of trouble. When the section was laid out in November the currents were all right; the trouble did not begin till the next June.

Method of locating section.

The section line should be made at right angles to the average direction taken by at least twenty rod-floats. The floats should be started from points not over 150 feet apart and about 100 feet above a preliminary section line taken at right angles to the shore line. The floats must be started from an anchored skiff; and with a sextant set at 90°, a line at right angles to the direction taken by the float should be staked off on shore. A mean of all these right-angle lines will be the best section line.

If the section is not a very good one the current on one side of the river may not run parallel with the current on the other side; in this case it might be best to make an angle in the section line.

Method of locating soundings and meter stations on section line.

Erect a line of signals on shore at right angles to the section line and up the river from it; make the length of the signal line one-fourth the width of the river. The signals must all be 25 feet apart, except the first six, which must be only 5 feet apart; make the width of the signal cloth 1 foot, and the height about 3 feet. Every fifth signal of those 25 feet apart should be double in height, so as to distinguish it from the others.

An ordinary sextant, or a cheap one made after the plan accompanying this report, must then be set at an angle of 14° 02′. This is an angle in a right-angled triangle, such that the base is four times the perpendicular; then every 25 foot space covered by the sextant will equal 100 feet out on the section line, and every fraction of 25 feet will equal such a fraction of 100 feet out. It is easy to read the distance in this way to within 1 or 2 feet. The sextant should be tested every morning by measuring with it the known distance across the river.

Location of velocity stations.

The velocity should be measured at at least 18 stations; that is the number now used at Carrollton, La. The velocity stations should be near together where the curve of velocity is sharp, and farther apart at other places. In order to save labor in computing, the stations should be located at the same distance from the base line every day; and the last two figures of the distance should be 00, 20, 40, 60, or 80.

In a large river where the wire anchorage cannot be used, the velocity stations should be fixed by diagonal range lines on shore and above the section. These range lines should not cross the section line at a sharper angle than 60°, and the nearer 90° it is the better.

Method of holding catamaran at the station.

Where the wire anchorage cannot be used, the catamaran should be lashed to the side of a launch and kept steady at the station by the pilot and engineer; great care being taken that the run of the meter begins and ends just on the section line.

The wire anchorage.

In a river which does not carry much drift the catamaran should be held in position by a wire anchorage laid about 15 feet above the section line.

The cross-wire should be made of No. 10 steel wire, and should be made in links 80 feet 2 inches long; the links must be joined by wrought-iron rings 2 inches in diamter; this makes the distance from station to station 80 feet, and allows 4 inches for the sag of the wire; experience teaches that this is about the right amount.

The cross-wire must be supported at each station by an anchor wire running up-stream to a rock weighing at least 250 pounds; the length of the anchor wire must be five times the depth of the water.

A machine for pulling the catamaran across on the wire should be used; it should be placed on a platform 3½ feet wide, which should project 4 feet ahead of the catamaran skiffs; this platform must be very strong.

The direction in which the catamaran is taken across the anchorage must be reversed every time. If the current is very swift the wire cannot be run twice in the same direction without breaking it, while if the direction is always reversed, it will last a long time. When the anchorage has been used some time, it is best to double the cross-wire; during high water it will probably be necessary to raise the cross-wire every day to prevent its becoming buried under the sand waves.

Method of using the meter.

The meter should be lowered from the stern of the catamaran by two No. 10 iron wires, one of which should be graduated to feet, and marked at every 10 feet by a red or white piece of cloth tied round it; the wire must be graduated by soldering to it a close winding of iron-thread wire, which should not be over $\frac{1}{100}$ of an inch in diameter. It requires about one hour for a party to graduate a wire in this way, and if properly done it will last three months. The other wire is the safety wire, and it has the insulated wire wound around it; it is necessary that the insulated wire be wound around the other, as if it is only tied to it, it will vibrate in the water and break in a short time where it is tied. The safety wire should be renewed occasionally to insure against losing the meter. These wires should run over large wooden pulleys 18 inches in diameter; small iron pulleys will break the wire in a short time.

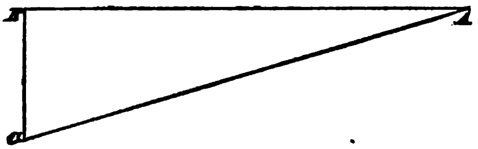
The electric circuit is formed by two wires, one of which is the iron graduated wire; the electricity passes from this to the iron reel on the catamaran, and is taken from the shaft of the reel by three brass springs which press against a copper band which is soldered around the shaft; the other wire is insulated, and is wound around the iron safety wire which runs off the other reel; the insulated wire passes down to the shaft of the reel, and out through a groove under the bearing to another copper band which is insulated from the shaft by pine wedges driven under it; three springs press against this band the same as on the other reel; two or more springs are necessary, as one will fail to carry the current occasionally.

The meter frame is allowed to turn both horizontally and vertically. It is fastened to the iron rod one foot above the weight; the rod should be three-fourths of an inch in diameter. The weight is linked to the rod so that the vane keeps it parallel with the current.

Integrations with the meter.

If integrations are to be taken with this apparatus, they must be taken in both directions, top to bottom and bottom to top, and a mean of the two used.

In the right-angled triangle A B C, let A B equal the distance the water runs while the meter is moving from the top to the bottom, and B C equal the depth of the water; then the line measured by the meter will be A C.



The meter must be lowered at such a slow rate that the line A B will be very long in proportion to B C, so that it will nearly equal A C.

Mid-depth velocities.

In taking the velocity at mid-depth, the meter must first be lowered to the bottom and the sounding read on the wire; divide this sounding by 2 for the mid-depth. Owing to the sag of the wire down stream, this sounding is greater than that taken with the lead-line, and must not be used in calculating the discharge.

Sounding the section.

The section should be sounded just before or just after the measurement of velocity, except where a wire anchorage is used; in that case the section can be sounded at the same time with the measurement of velocity.

The soundings should not average over 45 feet apart. The soundings should be read by both leadsman and recorder.

If an ordinary lead-line is used, it should be tested as follows: Just as soon as the soundings are finished, fasten the lead on the ground and tie a spring balance to the end of the line; give the line one quick pull and fasten it; make the pull just equal to the pull which the leadsman gives the line when he raises it to take the sounding; then measure the line and correct the soundings accordingly; remember that if the line is too short, the soundings are too great. With a 16-pound lead and 100 feet of line, the pull is about 26 pounds.

Method of reading gauge.

When the river is rough the gauge should be read with an instrument, a plan of which is inclosed. The instrument is clamped at an even tenth of a foot on the gauge; then the distance from the clamp to the water is read on the graduated plate which rises up in the center. A small hole near the bottom of the pipe lets in the water which lifts the air-tight float and graduated plate. When the waves are 6 inches high the gauge can be read with this instrument to within one or two-thousandths of a foot.

Method of measuring discharge when the river is frozen over.

When the river is covered with ice the meter must be put down through holes, and an apparatus, a plan of which is inclosed, should be constructed for the purpose.

It is a house on a sled and contains a stove, which is fed from the outside, a fuel box, a battery box, and two reels for lifting the meter, the handles to the reels being turned from the outside. It is large enough for one man only, and should be made as light as possible. The meter is lowered through a trap-door; one reel carries a standing wire with heavy weight, and the other carries a smaller wire with the insulated wire wound around it, which is fastened to the top of a piece of gas-pipe; the meter fastened to the gas-pipe slides up and down on the standing wire.

The electric current is carried by the insulated wire and the wire around which it is wound. It is taken from the hub of the reel by copper bands and springs, the same as are used on the catamaran; the standing wire should be graduated to feet.

Method of reading the gauge through the ice.

Cut a hole where the water is not over 4 or 5 feet deep, and drive in a stake with a round top; let the top of the stake be about 8 inches above the bed of the river; determine the elevation of the stake by leveling to a bench-mark; read the elevation of the water by measuring from the top of the stake to the surface of the water, using a graduated rod with a piece of board on the end, as shown in the plan accompanying this report. It will be necessary to melt the ice from the rod after each reading.

Rating of meter.

The meter should be rated in a lake of still water, which should not be less than 5 feet deep; put the meter on an iron rod so that it is free to swing in any direction; fasten the rod in front of a skiff so that the meter will be some distance under water; if the meter is too near to the surface or to the skiff, a good rating will not be obtained. Draw the skiff by means of a rope at different velocities over a base of 200 feet. Examine the meter occasionally to see if the connecting wires have not become twisted around the iron rod, so as to hold the meter out of line with the current.

All the ratings of a meter should be the same, unless the wheel has been bent.

All the methods, instruments, and every part of the apparatus given in this report have been used by me for a long time, and are known to work well. The drawings accompanying this report were made by Mr. M. K. Bowen, recorder.

Respectfully submitted.

W. G. PRICE,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

Discharge observations, Paducah, Ky.

This section, of which a sketch and profile are given below, was located 2¼ miles below the mouth of the Tennessee River. Parallel base lines, one on each shore, were fixed, and the observations taken on a line at right angles to these; the distance between bases was 4,100 feet. Velocity was taken at sixteen or seventeen stations on this line, and soundings for section were made at intervals varying from 50 to 100 feet.

Above the stage of 41 feet the Illinois bank was overflowed for a limited width. As this bank was covered with a dense growth, the shore-line at high stages was placed where the current became imperceptible.

At a stage of 43 feet, on the Kentucky side, the water reached the top of an old earthwork behind which was a depression, the bottom of which was at the 34-foot level. The water width and area of this depression were neglected in the field computations, but were included in the revision made in the office.

A peculiar feature of this section is that at this point the waters of the two rivers are still but imperfectly mingled, the flow of the Tennessee overlying that of the Ohio for some distance out from the Kentucky side. In consequence, the velocities taken by the meter at mid-depth, in this part of the section, being those of the underlying current (Ohio), which is here swifter than that of the Tennessee, are higher than the mean velocities indicated by integration measurements, while the corresponding rod-float velocities are regularly less than the mean. In the field computations this anomaly was disregarded, but in the office computations, these mid-depth velocities were corrected by the use of coefficients deduced from the velocity curves.

In the tables the mean gauge reading is given for noon, while the computations are based upon the gauge height at the mean time of observation.

Scour and fill is the difference between the change of area as observed and that computed from the change of gauge; scour is recorded as plus, fill as minus.

The datum stage was taken at 50 feet, and an area below this datum assumed. "Area below datum" for each discharge was obtained by combining the scour or fill with the preceding datum area.

The direction of the wind is recorded by the "clock-face" method, XII being upstream. Force is estimated on a scale of 1 to 10.

The computations from the beginning of observations to August 12 were made in the field; after that date in the office.

E. H. TWINING.

NOTE.—The discharge at this point is subject to the control of such varying conditions, that the plotted sheet shows frequent departures from a normal curve.

The conditions of control are—the stage of water at the mouth of the Ohio, that of the Upper Ohio, and that of the Tennessee.

* * * * * * *

OHIO RIVER.

Discharge observations at Paducah, Ky.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.								Air.	Water.		
			Water.	Below datum.	Mean.	Mean datum.	Maximum.									
1881.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*		°	°		
Dec. 22	25.39															
23	27.19	+1.80														
24	28.71	+1.52														
25	30.56	+1.85														
26	32.55	+1.99														
27	33.95	+1.40														
28	34.87	+0.92														
29	35.40	+0.53	161,753	226,806	39.7	49.4	60.5	4,071		4.557	787,187	VI 5			Rods.	
30	35.52	+0.12														
31	35.23	−0.29														
1882.																
Jan. 1	34.87	−0.36											16			
2	34.49	−0.38	163,306	229,373	40.4	50.0		4,039	+2,567	3.721	607,678	XII 3	25		M.	
3	34.30	−0.19					58.1						33			
4	34.39	+0.09											33			
5	34.41	+0.02											34			
6	34.18	−0.23	161,855	220,808	40.6	50.1	57.8	3,988	+ 435	3.741	605,568		38		M.	
7	33.79	−0.39	159,517	229,652	39.3	49.1		3,948	− 156	3.764	600,464		58		M.	Below bottom of slough.
8	33.48	−0.31											55			
9	33.46	−0.02	157,858	229,366	40.4	50.0		3,912	− 286	3.495	551,661	VI 3	41		M.	
10	33.64	+0.18					57.2						43			
11	34.41	+0.77	163,229	230,989	40.9	50.4	58.4	3,995	+1,623	3.751	612,205	VIII 3	38		M.	Slough included.
12	35.53	+1.12											37			
13	36.97	+1.44	174,904	232,147	41.7	50.6		4,197	+1,158	4.519	790,401		46		M.	
14	38.57	+1.60					62.8						40			
15	39.82	+1.25											49			
16	41.23	+1.41											37			
17	42.45	+1.22											18			
18	43.63	+1.18										II 3	25			
19	44.62	+0.99	207,403	234,130	47.4	51.0	70.6	4,376	+1,983	5.225	1,083,623	XII 3	29		M.	Above top of embankment.
20	45.55	+0.93										VII 2	36			
21	46.38	+0.83	214,180	234,508	47.8	50.4		4,420	+ 378	5.757	1,233,153	VI–VII 3	37		M.	
22	47.12	+0.74											30			
23	47.70	+0.58											34			
24	48.09	+0.39											39			

OHIO RIVER.—*Discharge observations at Paducah, Ky.*—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.		Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.									Air.	Water.		
			Water.	Below datum.	Mean.	Mean datum.	Maximum.										
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*			°	°		
Jan. 25	48.84	+0.25												45			
26	48.56	+0.22												59			
27	48.72	+0.16										VI	3	43			
28	48.74	+0.02	238,943	240,157	52.7	52.4	76.3	4,443	+5,649	5.211	1,218,974	XII	5	41		R.	
29	48.72	-0.02												23			
30	48.66	-0.06	232,758	239,283	52.4	52.2	75.7	4,443	- 874	5.152	1,199,194	VI	3	28		R.	
31	48.76	+0.10												28			
Feb. 1	48.79	+0.03												42			
2	48.77	-0.02	232,972	239,008	52.4	52.1	76.0	4,443	- 275	5.116	1,191,979	IX-X	2	43		R.	
3	48.71	-0.06	229,110	235,418	51.6	51.3	73.0	4,443	-3,595	5.262	1,205,518		1	38		R.	
4	48.48	-0.23												40			
5	48.11	-0.37												49			
6	47.58	-0.53												55			
7	47.09	-0.49												54			
8	46.50	-0.59												43			
9	45.82	-0.68															
10	44.96	-0.86	212,234	235,192	48.1	51.3	69.5	4,416	- 221	4.760	1,010,294	VI	2	42		R.	
11	43.93	-1.03												58			
12	43.18	-0.75												61			
13	43.16	-0.02												50			
14	42.99	-0.17	201,249	232,331	46.6	50.6	68.0	4,320	-2,861	4.512	908,017		1	48		M. A.	Top of embankment.
15	42.85	-0.14															
16	43.43	+0.58															
17	44.67	+1.24															
18	45.11	+0.44															
19	45.51	+0.40															
20	45.80	+0.29															
21	46.75	+0.95															
22	47.61	+0.86	223,104	234,063	48.7	51.0		4,584	+1,782	4.847	1,081,848	IX	3			M.	
23	48.52	+0.91					73.1										
24	49.32	+0.80															
25	49.77	+0.45	235,782	238,121	51.4	51.9	74.0	4,586	+4,058	4.980	1,174,161	VII	2			M.	
26	49.95	+0.18															
27	49.84	-0.11															
28	49.64	-0.20	237,025	238,126	51.7	51.9		4,587	+ 5	4.619	1,094,725	VII-VIII	1			M.	V. probably too low. Meter run at 9 stations.
Mar. 1	49.30	-0.34					76.0										
2	49.01	-0.29	238,289	237,165	50.9	51.7		4,585	- 961	4.798	1,119,246		2	60		M.	

	3	48.76	−0.25												62		
	4	48.37	−0.39	230,530	236,716	50.3	51.6	78.6	4,583	− 449	4.959	1,143,121		2	65		M.
	5	47.65	−0.72												58		
	6	46.96	−0.69												46		
	7	46.29	−0.67					71.1							38		
	8	45.48	−0.81	221,831	239,607	50.0	52.2	70.7	4,440	+2,891	4.651	1,031,841	III	4	43		M.
	9	45.34	−0.14												53		
	10	45.16	−0.18										XII	5	40		
	11	45.00	−0.16	213,000	235,247	48.0	51.3	70.2	4,440	−4,360	4.190	892,481	VI	1	45		M.
	12	45.15	+0.15												49		
	13	45.33	+0.18										I	5	46		
	14	45.37	+0.04	215,430	236,443	48.5	51.5	69.3	4,440	+1,196	4.475	963,963	VI	5	48		M.
	15	45.27	−0.10	215,251	236,588	48.5	51.6	......	4,440	+ 145	4.365	939,488	IX–X	4	64		M.
	16	44.96	−0.31					69.7							53		
	17	44.44	−0.52										VI	6	51		
	18	43.68	−0.76	211,390	237,234	47.9	51.7	69.8	4,415	+ 646	4.309	910,787	VII–VIII	2–4	70		M.
	19	42.91	−0.78												55		
	20	41.59	−1.32	198,367	236,036	45.7	51.5	......	4,340	−1,198	4.248	841,659	IX	6	70		M.	Below top of embankment.
	21	39.95	−1.64												46		
	22	38.00	−1.95												48		
	23	36.27	−1.73	171,815	231,870	41.5	50.5	......	4,137	−4,166	3.878	663,490	VIII–IX	5	50		M.
	24	35.28	−0.99												48		
	25	34.87	−0.41	167,721	233,722	41.4	50.9	60.6	4,033	+1,852	4.081	684,575	VII–VIII	6	58		M.
	26	34.85	−0.02												58		
	27	35.07	+0.22										IX	7	59		
	28	35.51	+0.44	168,513	232,760	41.2	50.7	60.3	4,085	− 962	4.110	692,309	III–IV	3	49		M.
	29	36.07	+0.56	172,273	233,309	41.6	50.9	61.2	4,135	+ 549	4.084	703,475	VIII	7	65		M.
	30	36.52	+0.45	173,846	233,064	41.9	50.8	61.5	4,149	− 245	4.041	702,388	III	3	55		M.
	31	36.88	+0.36												57		
Apr.	1	36.94	+0.06	176,398	233,794	42.3	50.9	63.6	4,170	+ 780	4.148	731,743	IX	3	69		M.
	2	36.54	−0.40												73		
	3	35.75	−0.79	168,876	231,073	41.0	50.4	60.6	4,120	−2,721	4.052	684,250	IX	3	73		M.
	4	34.30	−1.45	163,058	231,091	40.7	50.4	58.3	4,002	+ 18	3.859	629,105	IX	3	74		M.
	5	32.05	−2.25	153,673	230,733	39.8	50.3	......	3,860	− 358	3.685	566,358	IX	3	76		M.
	6	29.37	−2.68												71		
	7	26.50	−2.87	133,615	231,833	35.5	50.5	......	3,763	+1,100	3.118	416,670	VI	1	64		M.
	8	25.60	−0.90	130,368	231,871	34.6	50.5	50.5	3,762	+ 38	3.316	432,330	VI	1	68		M.
	9	26.11	+0.51												71		
	10	26.55	+0.44												50		
	11	26.60	+0.05	133,960	231,808	35.6	50.5	49.6	3,763	− 63	3.386	453,567	IV	5	39		M.
	12	26.23	−0.37												40		
	13	25.64	−0.59												47		
	14	25.11	−0.53	128,443	231,794	31.5	50.5	49.3	3,724	− 14	3.142	408,601	III	3	46		M.
	15	24.81	−0.30	127,109	231,592	34.1	50.5	48.8	3,722	− 202	3.051	387,817	XI	4	50		M.
	16	24.54	−0.27												51		
	17	24.11	−0.43	124,407	231,401	33.5	50.4	48.5	3,719	− 191	2.822	351,089	V	3	57		M.
	18	23.45	−0.66	121,934	231,312	32.8	50.4	......	3,718	− 89	2.664	324,873	VI–VII	3–5	61		M.
	19	22.75	−0.70												68		
	20	21.72	−1.03	114,411	230,216	31.0	50.2	45.9	3,695	−1,096	2.611	298,757	XII	3	69		M.
	21	20.64	−1.08												67		
	22	19.62	−1.02	106,287	229,894	28.8	50.1	43.6	3,693	− 822	2.495	265,133	VII	3	67		M.
	23	18.68	−0.94												54		

OHIO RIVER.—*Discharge observations at Paducah, Ky.*—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.								Air.	Water.		
			Water.	Below datum.	Mean.	Mean datum.	Maximum.									
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*		°	°		
Apr. 24	17.79	—0.89	99,507	229,870	26.6	50.1	41.4	3,690	— 24	2.247	223,624	VI 3	54		M.	
25	17.44	—0.35	98,060	229,876	26.6	50.1		3,690	+ 6	2.215	217,180	VI 3	66		M.	
26	17.79	+0.35											68			
27	18.35	+0.56	101,106	229,752	27.4	50.1	42.1	3,690	— 124	2.255	227,989	II–III 6	63		M.	
28	18.90	+0.55	103,303	229,742	28.0	50.1	42.7	3,690	— 10	2.329	240,600	Calm	61		M.	
29	19.40	+0.50											57			
30	19.73	+0.33											56			
May 1	19.90	+0.17	107,625	230,397	29.1	50.2	44.0	3,696	+ 655	2.365	254,516	VI 3	59		M.	
2	20.07	+0.17											60			
3	20.22	+0.15	108,663	230,252	29.4	50.2		3,696	— 145	2.474	268,779	VI 3–5	64		M.	
4	20.38	+0.16											78			
5	20.30	—0.08	109,383	229,950	29.6	50.1		3,696	— 302	2.480	271,322	VII–VIII 7	76		M.	
6	19.94	—0.36	108,275	229,943	29.3	50.1	44.0	3,696	— 7	2.487	269,261	IX 3	71		M.	
7	19.44	—0.50											71			
8	19.24	—0.20	105,257	229,814	28.5	50.1		3,694	— 129	2.533	266,668	VII 5	74		M.	
9	21.78	+2.54											65			
10	25.50	+3.72	130,344	231,872	34.6	50.5		3,766	+2,058	3.357	437,513	X 6	70		M.	
11	28.71	+3.21	142,806	232,170	37.9	50.6	53.4	3,768	+ 298	3.647	520,823	IX–X 3	63		M.	
12	31.51	+2.80											50			
13	32.96	+1.45											45			
14	33.18	+0.22											54			
15	32.98	—0.20	159,003	231,687	41.0	50.5		3,880	— 483	3.703	588,863	XII 6	55		M.	
16	32.82	—0.16	157,918	231,316	40.7	50.4	56.5	3,880	— 371	3.686	582,070	XII 1	55		M.	
17	32.93	+0.11	158,036	231,034	40.7	50.4		3,880	— 282	3.738	590,706	II–III 2	60		M.	
18	33.23	+0.30	159,297	231,156	40.9	50.4	57.0	3,892	+ 122	3.760	598,911	VI 1	65		M.	
19	33.51	+0.28											68			
20	33.77	+0.26	161,348	231,036	41.2	50.4	59.0	3,916	— 120	3.810	614,795	VIII 2–4	69		M.	
21	34.24	+0.47											54			
22	34.62	+0.38	163,542	229,904	41.1	50.1	58.0	3,976	—1,132	3.905	638,640	I 6	56		M.	
23	34.49	—0.13											58			
24	33.84	—0.65	159,425	228,791	40.6	49.9	56.8	3,928	—1,113	3.809	607,203	VI 2	64		M.	
25	32.84	—1.00	155,378	228,524	40.0	49.8	55.4	3,882	— 267	3.684	572,361	III 3	64		M.	
26	31.29	—1.55	148,678	228,115	39.0	49.7	53.6	3,815	— 409	3.528	524,580	VII 3–4	73		M.	
27	29.38	—1.91	141,697	227,832	37.5	49.7	52.4	3,774	— 283	3.281	464,952	VIII 5	75		M.	
28	28.69	—0.69											62			
29	26.38	—2.31											64			
30	26.32	—0.06	128,452	226,594	34.5	49.4	48.4	3,728	—1,238	3.078	395,335	V 1	67		M.	

	31	27.30	+0.98												66		
June	1	28.54	+1.24	137,634	227,460	36.6	49.6	50.8	3,764	+ 866	3.239	445,747	III-IV	3	63		M.
	2	29.29	+0.75	140,538	227,512	37.3	49.6	51.2	3,772	+ 52	3.318	466,349	VII-VIII	6	68		M.
	3	29.94	+0.65												66		
	4	30.61	+0.67												60		
	5	31.01	+0.40	147,478	227,824	38.7	49.7	52.6	3,815	+ 312	3.465	510,958	XI	3-5	65		M.
	6	31.28	+0.27	148,341	227,677	38.9	49.6	53.6	3,814	— 147	3.490	517,690	Calm		69		M.
	7	31.35	+0.07	148,720	227,747	39.0	49.7	53.1	3,814	+ 70	3.444 3.493	512,153 519,426	IX	3	70		M. R.
	8	31.10	—0.25	148,102	227,953	38.8	49.7	52.0	3,815	+ 206	3.447	510,470	IX	1	74		M.
	9	30.70	—0.40	145,854	227,205	38.4	49.5	51.8	3,800	— 748	3.359	489,983	VII	1	78		M.
	10	30.03	—0.67	143,321	227,140	37.9	49.5	50.6	3,788	— 65	3.188	456,843	VIII	1	80		M.
	11	29.00	—1.03												80		
	12	27.89	—1.11	134,945	227,180	35.9	49.5	49.1	3,758	+ 40	3.003	405,211	XI	3	74		M.
	13	26.13	—1.76	127,625	226,445	34.2	49.4	46.0	3,729	— 735	2.828 2.899	360,860 369,926	VIII	4	79		M. R.
	14	24.11	—2.02	120,625	226,681	32.4	49.4	45.1	3,719	+ 236	2.622	316,300	VIII-IX	5	83		M.
	15	22.30	—1.81	113,554	226,318	30.5	49.3	42.6	3,718	— 363	2.560	290,673	IX	3-4	80		M.
	16	21.08	—1.22												75		
	17	20.37	—0.71	105,838	226,342	28.5	49.3	40.9	3,710	+ 24	2.418	255,905	VI-VII	5	75		M.
	18	21.22	+0.85												75		
	19	23.30	+2.08												68		
	20	25.20	+1.90	125,262	227,404	33.6	49.6	46.1	3,730	+1,062	3.365	421,563	VI	3	69		M.
	21	25.72	+0.52												80		M.
	22	26.14	+0.42	128,010	226,703	34.3	49.4	46.7	3,736	— 701	3.364 3.292	430,630 421,243	V	1	82		M. R.
	23	26.36	+0 22	129,060	226,924	34.5	49.5	46.6	3,736	+ 221	3.336	430,565	XI	1	83		M.
	24	26.47	+0.11	129,467	226,898	34.7	49.5	46.8	3,736	— 26	3.267	423,008	IX	3	87		M.
	25	26.23	—0.24												88		
	26	25.73	—0.50	126,834	227,047	34.0	49.5	46.3	3,733	+ 149	2.973	377,085	IX	5	80		M.
	27	24.95	—0.78	124,136	227,119	33.3	49.5	45.1	3,724	+ 72	2.859	354,876	X	1	81		M.
	28	23.87	—1.08	119,979	227,118	32.2	49.5	44.3	3,724	— 1	2.768 2.568	332,107 308,979	X	5	83		M. R.
	29	22.85	—1.02												82		
	30	21.95	—0.90	113,480	227,561	30.5	49.6	42.2	3,724	+ 443	2.460	279,200	X	7	82		M.
July	1	22.25	+0.30	114,678	227,824	30.8	49.7	42.7	3,724	+ 263	2.531	290,239	IX-X	6	82		M.
	2	22.16	—0.09												79		
	3	22.23	+0.07	113,527	226,863	30.5	49.5	42.6	3,724	— 961	2.326	264,121	VIII	3	72		M.
	4	22.90	+0.67												67		
	5	23.47	+0.57	118,495	227,349	31.8	49.6	43.9	3,728	+ 486	2.364	280,169	I	6	67		M.
	6	24.27	+0.80	121,357	226,973	32.5	49.5	44.7	3,732	— 376	2.369 2.300	287,549 279,105	V	3	70		M. R.
	7	24.87	+0.60												69		
	8	25.25	+0.38	124,790	226,795	33.4	49.4	45.7	3,736	— 178	2.495	311,323	VIII-IX	4-5	78		M.
	9	25.25	0												78		
	10	24.88	—0.37	123,109	226,358	33.0	49.3	45.2	3,736	— 437	2.314	284,910	VIII	4-5	79		M.
	11	24.47	—0.41	121,097	226,060	32.4	49.3	44.8	3,736	— 398	2.367	286,660	IV	2	79		M.
	12	23.80	—0.67												81		
	13	22.78	—1.02												72		
	14	21.68	—1.10	110,817	226,091	29.7	49.3	41.3	3,736	+ 31	2.295	254,337	Var.	3	69		M.
	15	20.83	—0.85	108,322	226,713	29.1	49.4	41.0	3,720	+ 622	2.369 2.347	256,626 254,212	VI-VII	3	72		M. R.

OHIO RIVER.—*Discharge observations at Paducah, Ky.*—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.		Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area. Water.	Area. Below datum.	Depth. Mean.	Depth. Mean datum.	Depth. Maximum.							Air.	Water.		
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*			°	°		
July 16	20.16	—0.67												77			
17	19.54	—0.62	102,946	226,085	27.7	49.3	39.5	3,716	— 628	2.492	256,583	VI–VII	1	75		M.	
18	18.68	—0.86												78			
19	17.79	—0.89	95,622	225,524	25.8	49.2	36.4	3,700	— 561	2.386 2.254	228,193 215,560	III	3	75		M. R.	
20	17.00	—0.79	93,006	225,576	25.1	49.2	37.1	3,700	+ 52	2.304	214,288	VI	1	74		M.	
21	16.33	—0.67	90,903	226,062	24.6	49.3	36.0	3,698	+ 486	2.295	208,664	X	1	70		M.	
22	15.89	—0.44	88,740	225,538	24.0	49.2	35.5	3,694	— 529	2.247	199,430	VI	3	72		M.	
23	15.32	—0.57												75			
24	14.46	—0.86	83,600	225,327	22.7	49.1	34.8	3,686	— 206	2.069	172,977	VI	1	75		M.	
25	13.39	—1.07	79,353	225,151	21.5	49.1	33.1	3,683	— 176	1.973 1.877	156,536 148,957	VI	2	78		M. R.	
26	12.19	—1.20												78			
27	11.06	—1.13	71,323	225,623	19.5	49.2	31.1	3,662	+ 472	1.877	133,874	V	1	76		M.	
28	10.21	—0.85	68,373	225,638	18.7	49.2	30.1	3,656	+ 215	1.862	127,331	VIII	3	76		M.	
29	0.61	—0 60	65,859	225,539	18.0	49.2	29.8	3,654	— 299	1.895	124,834	V–VI	3	76		M.	
30	9.17	—0.44												79		M.	
31	8.70	—0.47	61,976	225,181	17.0	49.1	27.7	3,644	— 358	1.878	116,419	IX	3–4	80		M.	
Aug. 1	8.36	—0.34	60,851	225,342	16.7	49.1	28.2	3,643	+ 161	1.834	111,584	VII	3	81		M.	
2	8.22	—0.14	60,881	225,904	16.7	49.2	27.1	3,642	+ 562	1.887 1.777	114,855 108,165	IX	5	76		M. R.	
	8.11	—0.11	60,269	225,598	16.5	49.2	27.7	3,642	— 306	1.898	114,388	XI	3	77		M.	
4	8.18	+0.07	60,074	225,341	16.5	49.1	28.0	3,640	— 257	1.979	118,916	III	1	75		M.	
5	8.98	+0.80	62,029	225,365	17.2	49.1	27.6	3,643	+ 24	2.161	135.371	VI	4	74		M.	
6	10.72	+1.74												79			
7	12.08	+1.36	73,913	225,141	20.1	49.1	30.7	3,668	— 224	2.553	188,668	IX–X	3	76		M.	
8	12.49	+0.41	75,701	225,156	20.6	49.1	32.2	3,672	+ 15	2.627	198,889	XII	7	77		M.	
9	12.52	+0.03	75,940	225,230	20.7	49.1	32.2	3,672	+ 74	2.505	190,263	XI	4–5	70		M.	
10	12.39	—0.13	75,544	225,319	20.6	49.1	32.1	3,672	+ 89	2.514 2.415	189,943 182,438	I–II	3	67		M. R.	
11	12.44	+0.05	75,531	225,126	20.6	49.1	32.2	3,674	— 193	2.544	192,170	Calm		68		M.	
12	12.50	+0.06	75,652	225,228	20.7	49.1	32.2	3,674	+ 97	2.557	193,930	IV–V	3	69		M.	
13	12.31	—0.19												77			
14	11.96	—0.36	73,837	224,949	20.1	49.0	31.5	3,670	— 274	2.538	187,384	VIII–IX	3	78		M.	
15	11.56	—0.39	72,771	225,401	19.8	49.2		3,670	+ 512	2.480	180,454	VIII–IX	3	77		M.	
16	11.41	—0.15	72,332	225,646	19.7	49.2	31.2	3,668	+ 185	2.476	179,108	IX–X	2	76		M.	

	17	11.81	−0.10	71,855	225,609	19.6	49.2	......	3,668	−	87	2.548 2.501	188,069 179,708	I	6	75	....	M. R.
	18	11.24	−0.07													73	....	
	19	11.13	−0.11	70,902	225,389	19.3	49.1	30.8	3,667	−	220	2.523	176,825	IV	5	73	....	M.
	20	10.89	−0.24													72	....	
	21	10.43	−0.46	68,938	225,021	18.8	49.1	30.1	3,660	−	368	2.430	167,581	V-VI	3	78	....	M.
	22	9.83	−0.60	66,438	224,429	18.2	48.9	29.8	3,658	−	593	2.328	154,697			80	....	M.
	23	9.13	−0.70	63,611	224,197	17.4	48.9	......	3,652	−	232	2.243 2.231	142,681 141,903	VI	3-4	78	....	M. R.
	24	8.44	−0.69	61,495	224,489	16.9	48.9	27.9	3,646	+	292	2.170	133,434	IX	5	74	....	M.
	25	7.88	−0.56	59,184	224,655	16.8	49.0	......	3,639	+	166	2.106	124,618	VII	3	75	....	M.
	26	7.37	−0.51	57,655	224,980	15.9	49.0	26.9	3,632	+	325	2.015	116,157	XI-XII	4	75	....	M.
	27	7.00	−0.37															
	28	6.79	−0.21	56,098	225,846	15.7	49.1	26.4	3,626	+	366	1.954	109,599	I-II	4	71	....	M.
	29	6.57	−0.22	54,953	225,035	15.2	49.1	......	3,624	−	311	1.898	104,327	III	3	73	....	M.
	30	6.72	+0.15	55,408	224,729	15.3	49.0	26.4	3,625	−	306	1.952 1.917	108,169 106,190	VI	1	73	....	M. R.
	31	6.98	+0.26	56,145	224,777	15.5	49.0	......	3,628	+	48	2.026	118,753	XII	3-4	74	....	M.
Sept.	1	7.15	+0.17	56,818	224,688	15.7	49.0	26.9	3,630	−	39	2.055	116,776	VI	3	73	....	M.
	2	7.42	+0.27													67	....	
	3	7.67	+0.25													70	....	
	4	7.86	+0.19	59,020	224,346	16.2	48.9	27.4	3,638	−	342	2.123	125,819	II	3	72	....	M.
	5	7.98	+0.12	59,272	224,234	16.3	48.9	......	3,640	−	112	2.158	127,925	II-III	3	69	....	M.
	6	8.38	+0.40	61,027	224,204	16.7	48.9	28.0	3,646	−	30	2.226	135,818	III	3	71	....	M.
	7	8.90	+0.52	62,557	224,093	17.1	48.9	......	3,648	−	111	2.322	145,262	IX-X	5	69	....	M.
	8	9.25	+0.35	63,735	223,958	17.5	48.8	28.9	3,648	−	135	2.352	149,905	Var.	1	72	....	M.
	9	9.30	+0.05	63,845	223,959	17.5	48.8	......	3,648	+	1	2.354	150,293	III-IV	5	71	....	M.
	10	9.01	−0.29													68	....	
	11	8.64	−0.37													65	....	
	12	8.14	−0.50	59,805	224,401	16.4	48.9	27.4	3,639	+	442	2.155	128,888	VI	5	65	....	M.
	13	7.69	−0.45	58,640	224,618	16.1	49.0	......	3,635	+	217	2.181 2.044	124,969 119,867	IX	6	74	....	M. R.
	14	7.37	−0.32	57,487	224,809	15.8	49.0	26.9	3,632	+	191	2.003	115,087	IX	3	76	....	M.
	15	7.08	−0.29	57,105	225,298	15.7	49.1	26.2	3,629	+	489	2.011	114,816	IX	1	77	....	M.
	16	7.44	+0.36	58,206	225,310	16.0	49.1	......	3,633	+	12	2.084 2.067	121,297 120,284	VI	1	80	....	M. R.
	17	9.23	+1.79													74	....	
	18	10.69	+1.46	69,693	225,133	19.0	49.1	......	3,661	−	177	2.615	182,228	IX	6	77	....	M.
	19	11.93	+1.24	74,513	225,041	20.3	49.1	31.6	3,670	−	92	2.780	207,136	IX	5	75	....	M.
	20	12.65	+0.72	76,910	224,831	20.9	49.0	......	3,676	−	210	2.870	220,751	XII	2	67	....	M.
	21	12.27	−0.38											XII-I	6	55	....	
	22	11.23	−1.04	72,073	224,913	19.7	49.0	30.3	3,666	+	82	2.541	183,124	I	4	56	....	M.
	23	10.15	−1.08	67,906	224,828	18.6	49.0	......	3,658	−	85	2.388 2.406	162,364 163,899	I	2	60	....	M. R.
	24	9.38	−0.77													61	....	
	25	8.70	−0.68	60,932	224,959	16.7	49.0	......	3,647	+	131	2.211	134,835	III	4	60	....	M.
	26	7.86	−0.84	59,544	224,809	16.4	49.0	26.3	3,634	−	150	2.091	124,628	III	5	59	....	M.
	27	7.15	−0.71													59	....	
	28	6.52	−0.63	54,772	225,009	15.1	49.1	......	3,624	+	200	1.926 1.905	105,487 104,355	VI	6	65	....	M. R.
	29	6.13	−0.39	53,405	225,168	14.8	49.1	25.8	3,619	+	154	1.887	100,764	IX	5	69	....	M.
	30	5.82	−0.31	52,427	225,126	14.5	49.1	......	3,616	−	37	1.850	96,969	VII	1	70	....	M.

OHIO RIVER.—*Discharge observations at Paducah, Ky.*—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area. Water.	Area. Below datum.	Depth. Mean.	Depth. Mean datum.	Depth. Maximum.						Air.	Water.		
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*		°	°		
Oct 1	5.54	−0.28											70			
2	5.40	−0.14	50,660	225,022	14.0	49.1	24.4	3,613	− 104	1.778	90,988	IV-V 1	71	......	M.	
3	5.69	+0.29	51,755	224,816	14.3	49.0	24.6	3,616	− 206	1.832	94,830	Calm.	72	......	M.	
4	5.96	+0,27	52,276	224,541	14.4	49.0	......	3,619	− 275	1.900 1.881	99,333 98,350	VI 3	70	......	M. R.	
5	6.04	+0.08	52,577	224,552	14.5	49.0	25.4	3,620	+ 11	1.909	100,255	VII 1	69	......	M.	
6	6.04	0	52,403	224,430	14.5	48.9	......	3,620	− 122	1.918	100,608	VII 3	69	......	M.	
7	6.01	−0.03	52,326	224,402	14.5	48.9	25.2	3,620	− 28	1.899	99,392	VII 5	69	......	M.	
8	5.97	−0.04											70			
9	6.01	+0.04	52,670	224,818	14.6	49.1	25.2	3,620	+ 416	1.898	100,000	VIII-IX 1	70	......	M.	
10	6.09	+0.08											71			
11	6.05	−0.04	52,776	224,743	14.6	49.0	25.2	3,020	− 75	1.894	99,964	I 3	58	......	M.	
12	5.83	−0.22	51,904	224,667	14.3	49.0	......	3,019	− 76	1.862 1.825	96,668 94,709	VII 5	65	......	M. R.	
13	5.61	−0.22											67			
14	5.24	−0.37	49,934	224,578	13.8	49.0	24.6	3,616	− 89	1.776	88,670	VI 3-4	60	......	M.	
15	4.90	−0.34											64			
16	4.61	−0.29	47,570	224,742	13.2	49.0	......	3,607	+ 164	1.632	77,654	VII-VIII 5	67	......	M.	
17	4.41	−0.20											58			
18	4.13	−0.28	45,521	224,495	12.6	48.9	23.2	3,600	− 247	1.567	71,329	II 4	52	......	M.	
19	3.97	−0.16	45,140	224,654	12.5	49.0	......	3,599	+ 159	1.556	70,241	II 6	58	......	M.	
20	3.77	−0.20	44,273	224,579	12.3	49.0	23.1	3,598	− 75	1.473	65,235	III 5	58	......	M.	
21	3.56	−0.21	43,695	224,541	12.1	49.0	......	3,597	− 38	1.420	62,066	V 3	52	......	M.	
22	3.44	−0.12											54			
23	3.35	−0.09	42,840	224,549	11.9	49.0	......	3,595	+ 8	1.407	60,257	XI-XII 4	54	......	M.	
24	3.23	−0.12	42,424	224,564	11.8	49.0	......	3,594	+ 15	1.375 1.340	58,314 56,862	VI 3	55	......	M. R.	
25	3.16	−0.07	42,110	224,503	11.2	48.9	22.5	3,594	− 62	1.380	58,129	IX 6	64	......	M.	
26	3.14	−0.02	42,070	224,570	11.1	49.0	22.4	3,594	+ 68	1.339	56,319	X 1	64	......	M.	
27	3.18	+0.04	42,221	224,577	11.7	49.0	......	3,595	+ 7	1.371	57,886	IX 7	68	......	M.	
28	3.37	+0.19	42,896	224,569	11.9	49.0	......	3,596	− 8	1.432	61,417	VIII 6	65	......	M.	
29	3.54	+0.17											59			
30	3.43	−0.11	43,185	224,534	12.0	48.9	......	3.597	− 85	1.452	62,711	VIII 6	67	......	M.	
31	3.33	−0.10	42,822	224,567	11.9	49.0	22.7	3,599	+ 83	1.402	60,038	VI-VII 3-4	70	......	M.	
Nov. 1	3.25	−0.08	42,841	224,410	11.8	48.9	......	3,597	− 157	1.309 1.347	57,971 57,051	IX 3-4	71	......	M. R.	
2	3.17	−0.08	41,850	224,315	11.6	48.9	22.3	3,595	− 95	1.345	56,299	II-III 3	56	......	M.	

3	3.06	−0.11	41,548	224,265	11.6	48.9	......	3,594	− 50	1.298	53,949	III 1	56	....	M.
4	2.98	−0.08	41,245	224,249	11.5	48.9	22.8	3,593	− 16	1.324	54,623	V-VI 3-4	55	....	M.
5	2.94	−0.04	....	....	......	....	......	....	....	....	....	....	57	....	......
6	3.00	+0.06	41,308	224,240	11.5	48.9	......	3,598	− 9	1.381	57,044	VIII-IX 5	58	....	M.
7	3.15	+0.15	41,815	224,208	11.6	48.9	22.3	3,594	− 82	1.356	56,685	VI 1	54	....	M.
8	3.30	+0.15	42,484	224,324	11.8	48.9	......	3,596	+ 116	1.436	60,937	VI-VII 3	59	....	M.
9	3.52	+0.22	43,159	224,294	12.0	48.9	......	3,598	− 80	1.449	62,541	IX 3-5	62	....	M.
10	4.11	+0.59	45,116	224,306	12.5	48.9	......	3,604	+ 12	1.532	69,130	VIII 5	67	....	M.
11	4.35	+0.24	46,298	224.401	12.8	48.9	23.9	3,608	+ 95	1.657	76,728	VII-VIII 6	65	....	M.
12	4.62	+0.27	....	....	......	....	......	....	....	....	....	....	49	....	......
13	5.10	+0.48	....	....	......	....	......	....	....	....	....	....	33	....	......
14	4.90	−0.20	48,078	224,164	13.3	48.9	......	3,618	− 237	1.718	82,588	VIII 6	40	....	M.
15	4.77	−0.13	47,397	224,061	13.1	48.8	23.9	3,615	− 108	1.714	81,259	I 1	44	....	M.
16	4.73	−0.04	47,554	224,326	13.2	48.9	......	3,616	+ 265	1.674 1.701	79,595 80,913	VIII-IX, 3-5	47	....	M. R.
17	4.91	+0.18	....	....	......	....	......	....	....	....	....	....	44	....	......
18	5.15	+0.24	....	....	......	....	......	....	....	....	....	....	41	....	......
19	5.14	−0.01	....	....	......	....	......	....	....	....	....	....	40	....	......
20	5.03	−0.11	48,945	224,523	13.5	48.9	......	3,620	+ 197	1.761	86,177	II-III 5	38	....	M.
21	4.87	−0.16	48,445	224,602	13.4	49.0	23.5	3,618	+ 79	1.770	85,761	XI 4-6	38	....	M.
22	4.70	−0.17	47,759	224,603	13.2	49.0	......	3,615	+ 1	1.681	80,296	VI 1	42	....	M.
23	4.64	−0.06	....	....	......	....	......	....	....	....	....	....	41	....	......
24	4.57	−0.07	47,153	224,502	13.1	48.9	23.8	3,601	− 101	1.657	78,137	XII 4	33	....	M.
25	4.47	−0.10	46,833	224,506	13.0	48.9	......	3,600	+ 4	1.654	77,445	VI 3	37	....	M.
26	4.54	+0.07	....	....	......	....	......	....	....	....	....	....	42	....	......

2.—AT COLUMBUS, KY., J. H. DAVIS, ASSISTANT IN CHARGE.

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., July 7, 1883.

SIR: I have the honor to submit the following report on the observations made at Columbus, Ky., from December 17, 1881, to November 25, 1882. The work consisted of:

1st. Discharge observations.
2d. Determining vertical velocity curves.
3d. Determining transverse velocity curves.
4th. Longitudinal soundings.
5th. Cross-section soundings.
6th. Experiments on subsurface currents.

Preliminary work.—The party, consisting, at first of assistant, recorder, and three boatmen, reached Columbus on the 29th of November. After locating, operations were begun by making a reconnaissance of the river in front of town for the purpose of selecting a suitable gauging section. This being completed, several days were occupied in making the necessary preparations for the work in view. These were delayed somewhat on account of having shipped most of the material to Natchez, the place at first selected for the observations. It was not returned to Columbus till December 7, nine days after the arrival of the party. Meanwhile the party were employed in building a catamaran and making such utensils as were needed in manipulating the meter. Range lines were also laid off, and signals made and erected upon them. A water-gauge was put up, and tri-daily observations upon the stage of the river commenced. The preliminaries having been completed, the first discharge measurements were made on the 17th of December.

Statement.—The discharge observations were made daily, Sundays excepted. From December 17, 1881, to November 25, 1882, there were made in all 243 sets of discharge observations. Of these, 8 sets were made with double floats, 83 sets with rod-floats, and 152 sets with the current meter. Frequent omissions occurred in the early part of the work on account of bad weather and accidents to instruments and machinery.

Usually the observations for a vertical curve were made upon each day that the meter was used in the discharge measurements. There were frequent omissions, however, owing to a lack of time. During the year there were 101 curves determined. They were distributed across the river so as to include all depths and velocities.

The transverse velocity observations were made monthly. Owing to high water and the frequent repairs to the launch, they were not begun till the last of March. From that time until the close of the work 8 curves were determined. They extend over a period that includes all the stages of the river from high to low.

The longitudinal soundings were made weekly when the time was not fully occupied with more important work. There were 31 sets made during the year, a set consisting of from 12 to 15 lines of soundings over a reach of 500 feet.

The cross-section soundings were made for the purpose of determining the amount of scour or fill, in sharp bends, due to certain changes in the stage of the river. They were all made on one section, and at oscillations of about 3 feet on the gauge. From May to November, 11 sets of about 75 soundings were made.

The experiments on the direction of subsurface currents were unsuccessful. The apparatus could not be made to do the work for which it was designed. The results were wholly unreliable and were not recorded.

Discharge observations.—These may be divided into three classes: 1st, observations made with double floats; 2d, observations made with rod-floats; 3d, observations made with a current meter. The last two admit each of a subdivision, as will be seen from a description of the methods employed.

From December 17 to 28, inclusive, the double floats were used in discharge measurements, there being no other method practicable at the time. They were of the pattern of those used by Assistant W. H. Powless, at Fulton, Tenn., a small cord being used for connecting the surface and subsurface parts.

On December 29, in accordance with instructions, rods were substituted for double floats. They consisted of tin tubes 1¼ inches in diameter, connected and buoyed by a wooden rod of the same diameter. The tubes were perforated so as to admit the water freely. The rod thus constructed was immersed about 37 feet in deep water. This varied from one-third to one-half the greatest river depth on the gauging section. Rod-floats were used with few exceptions until March 18, and at intervals of about two weeks during the remainder of the observations. In all observations previous to March 1, the floats were located in one point of their paths only, and by means of the telemeter (see description). After that date, they were located in two points, by means of a transit. On the 12th of September, a goniometer was substituted for the transit.

The instructions were to use the current meter in discharge measurements, but it was not practicable to do so in the early part of the work. It could not be used without the launch, which did not arrive till the 25th of December, and was not serviceable for more than a month following, except for very short periods. The meter was first used on January 24, but with only partial success. It was also used on the 27th and 28th, and a few times in February. From the middle of February to the middle of March, the high water and heavy drift rendered it very difficult to get a complete discharge measurement with the meter at all, and at best the work was very unsatisfactory. During a week of the time, also, the launch was at Cairo for repairs.

It being very desirable to have a complete set of observations over this the highest stage of the river, not only of that year, but then on record, it was thought advisable to use rod-floats exclusively, that being a surer method of obtaining complete results. After March 18, the meter came into constant use, the water having fallen sufficiently to handle it with safety and comparative ease. The rod-floats were still used at intervals of about two weeks, in accordance with instructions, and sometimes oftener, when the meter needed repairing. After and including March 18, with few exceptions, the boat was anchored during the observations with the meter. Previous to that time, the observations were made without anchoring. Both methods are described below.

METHODS.

Double floats.—Two ranges were laid off, 100 feet apart, and as nearly parallel as was practicable, with no better instrument than a cloth tape-line. They were also practically at right angles to the thread of the current.

On these ranges front and back signals were erected on both shores, and also intermediate ones for use in measuring distances with the telemeter. The floats were manipulated by an observer in a skiff. The connecting cord was made of sufficient length to allow the subfloat to run practically at mid-depth, the limit being between four-tenths and six-tenths of the depth. The float was put out far enough above the upper range to assume a uniform rate before reaching it. The skiff was kept in line with the float and at a convenient distance behind it, while passing the ranges. The distance from shore was measured by the observer in the skiff, when he reached a point about midway between the two ranges, the telemeter being used for this purpose. Soundings were taken on each range by a leadsman in the bow of the skiff. After passing the lower range, the float was picked up, the skiff rowed above line, and the operation repeated for each successive observation. The float was timed by an observer on shore, who watched its crossing of the ranges, and at the same time manipulated a stop-watch. To aid him in determining when the float crossed the ranges, a fine vertical wire was employed at each of the range stations. By standing just behind it, and keeping it in line with himself and the signal across the river, the time of the floats crossing could be determined with tolerable exactness. A field-glass was also used, through which the wire, the signal across the river, and the float, could be distinctly seen at the same time.

The actual float-path could not be measured by this method. In the computations it was considered 100 feet. In most cases it was greater, and where great accuracy is desired, the length of path should be corrected by those determined afterwards at corresponding stages, by use of the transit.

Rod-floats.—(1). Previous to the use of the transit, March 1, the method of using rod-floats was the same as that for double floats, except that they were not run at mid-depth. With few exceptions 37 feet was the immersion used in deep-water observations. That for shallow water was regulated by the sounding, the float being run as near the bottom as practicable without touching.

Rod-floats.—(2). A B. & B. transit (No. 237) was received the latter part of February, and brought into immediate use in the discharge observations with floats. The range lines were tested and found but slightly out. A base line of 515 feet was laid off at right angles to the ranges, and a transit station established at its extremity. A telegraph line was erected for the purpose of signalling from the station on the ranges to the transit station. A key was placed in the circuit at each of the range stations and a sounder at the transit station. The circuit was left open and could be closed by touching either key. The floats were handled from a skiff, the launch being used for towing it above the ranges. The boatmen were necessarily relied upon for correct manipulation of the float as well as the taking and recording of the soundings. The transit being in position and properly set with the lower plate clamped, the battery and all being in perfect working order, the following programme was carried out for each observation:

The float was spliced and lowered some distance above the upper range, so as to assume an erect position and uniform movement before reaching it. An observer on the upper range watched the float until it came within a few feet of line, when he touched his key twice, for a ready signal to the observer at the transit. When the float reached the range the observer touched his key once and immediately went to the lower range. Here the same signals was given as on the upper range.

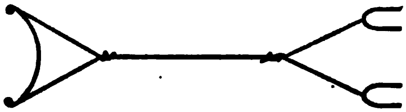
The observer at the transit having brought the float into his field of view, followed it without clamping until the first signal came from the observer on the upper range. He then clamped the vernier plate and followed the float by turning the tangent screw until the second signal came. He immediately stopped the motion of the screw and read and recorded the angle; unclamping the vernier plate, he again caught the float in the field of view, and followed it until the signals came, from the lower range, when the manipulations were the same as above.

The time was taken with an ordinary watch by an observer at the transit station. The watch was read at each crossing signal. The difference of the two readings was taken for the time of passage. To aid the observer in reading fractions of a second, a microscope was used. By means of it, the watch could be read to quarter seconds.

A discharge measurement with floats consisted of from 20 to 25 observations distributed equally across the river.

The current meter.—(1.) When anchored.—The meter was handled from a catamaran swinging from the launch at anchor. The latter was held by one bow anchor, requiring, at high stages, the aid of the engine to prevent drifting.

The catamaran, which was of the usual construction, was connected with the launch in the following manner: The ends of a rope were attached respectively to the stern kevels of the launch, allowing a few feet of slack; another rope was similarly attached to the outer bow kevels of the catamaran. The middle points of these were connected by a third rope, of variable length, forming a double Y, thus:



The whole plant, consisting of the launch and catamaran, together with the anchor rope, was free to swing with the current. The distance between the launch and catamaran was varied to suit the requirements of the wind, and the depth and velocity of the water. It was necessary, with a strong up-stream or cross-stream wind and a slow current, to bring the catamaran in close proximity to the launch. The greatest distance employed was about 75 feet.

The meter was lowered from the back part of the catamaran. To do this it was first clamped to a rod, let into a leaden weight of 60 pounds, cylindrical in shape. On the upper part of the rod was a movable ring for attaching the lowering wire.

The meter, thus clamped to the rod and weight, was suspended by a No. 11 annealed steel wire, that passed over a pulley at the back of the catamaran, and thence around a reel conveniently near. To overcome, as much as possible, the action of the current in carrying the meter down stream, a guy-cord of ¼ inch cotton was attached to the rod above the meter, passed over a pulley at the stern of the launch, and thence around a second reel on the catamaran. The meter was lowered or raised by the simultaneous though unequal turns of the two reels. The relative rates at which the two reels should be turned, to send the meter down vertically, had to be acquired tentatively, rather than from computed tables, for this relation varied with the distance between the launch and the catamaran, and also with the velocity of the current. The dexterity of the men at the reels increased with experience, the man at the guy-reel having nothing to guide him but the tension on his cord. With the greatest precision the meter could not be sent down on a vertical in high stages of the river, as was shown by the difference between the down and up integrations. However, by taking the mean of these, there was practically no error resulting from the above fact.

The following programme was carried out in measuring discharges with the meter:

The launch, with the catamaran tied close astern, was run some distance above the discharge section, the distance out being obtained approximately by means of signals on shore. The desired position having been reached, the anchor was cast and the boat allowed to drift toward the discharge section. When sufficiently near it, the boat was checked by fastening the anchor rope around a kevel, and, if necessary, starting the engine. The catamaran was now let down to the discharge section, by means of the connecting ropes already described. The sounding was taken while drifting into position, the lead being cast in time for the line to become vertical before the discharge section was reached. The observer recorded the sounding, and measured the distance from shore by means of the telemeter. He also estimated, by guess, the direction and force of the wind. The depth being known, the number of turns of the main lowering reel required to let the meter to the bottom could be estimated approximately. This number was called out by the observer, and the men at the reels prepared for integrating, by lowering the meter until the buckets were barely covered with water. At the signal "time" from the observer, the meter was started down at a uniform rate, not exceeding one-half foot per second, the man at the main reel counting the turns. At the instant of giving signal the observer noted the watch time, and started the electrical register, by turning on the switch.

When the meter reached a point within a few turns of the bottom, the man at the reel called out "ready," and upon feeling the weight touch, he called "time" and immediately reversed his reel. When the time signal was called, the observer noted the watch time, and read the register without stopping it.

To obtain both the time and the register reading correctly required some skill, especially during high water. It can be done by the observer keeping in mind the reading of the last dial only, from the sound of the register, counting the ticks, one, half, two, half, &c.

When time is called, the seconds of the watch time, and the reading of the last dial of the register, can be jotted down hastily, while the hour and minutes of the time and the readings of the remaining dials of the register can be obtained at leisure. With a little practice the nearest second of time and the nearest half revolution of the meter wheel can be accurately obtained by the same observer. The meter was returned to the surface at the same rate as that of the descent, the man at the reel calling "time" when the starting point was reached. The observer again read the watch and stopped the register, recording the readings of both.

If the results of integration were satisfactory, the meter was now lowered for mid-depth observations. This was done by giving the main reel one-half the number of turns required to send the meter to the bottom. The meter was run at mid-depth for at least five minutes, the register being read at the end of each minute. When it was possible to hold the boats in one position the meter was run a whole number of minutes at mid-depth; otherwise it was run as described in the method without anchoring.

Great care was exercised by the engineer and steersman to hold the boats in one position during the observation, using the engine when necessary to assist the anchor. Even when not needed the engine was kept moving slowly, except in extreme low water, in order to prevent the wheel of the launch from retarding the current near the surface. In extreme low water the engine could not be run without changing the position of the boat.

The current meter.—(2.) Without anchoring.—Only mid-depth observations were taken in this way, and at times when anchoring was not practicable. The method differs but slightly from that given above. After drifting into position, the sounding having been taken, the launch was held as nearly in one position as was possible by the careful watchfulness of the steersman and engineer. The meter being lowered to mid-depth, as estimated from the sounding, the catamaran was brought to the gauging section, when the time was noted and the register started. The engineer, standing with his hand on the throttle-valve, was able to keep the boat almost on the same range during the observation. If, however, at the end of five minutes, the catamaran should be a little above or below the gauging section it was brought into position, when the time was again noted and the register stopped. The readings of the latter were taken and recorded at the end of each minute, and also at the close of the observation.

The fact of starting and stopping the meter register on the same range practically destroyed the effects of any movement up and down stream during the observation. The errors due to lateral movement are not so easily compensated, as the rate of the meter is accelerated by a movement in either direction. Such errors were comparatively small, however, except in cases of very high wind, when the boat was liable to shift its position to a considerable extent in a lateral direction.

A set of discharge observations with the meter, consisted of velocities at mid-depth and by integration, when anchored, and at mid-depth when not anchored, at from 12 to 15 stations across the river on the gauging section. A sounding was taken at each station; as the bottom was very even, this was thought sufficient to give a correct area of the section.

METERS AND METER-RATING.

The Ellis meter was employed exclusively. During the year Nos. 3, 6, and 23 were used at different periods. At times the meter in use was not in the best of order, owing to the exceeding delicacy of the instrument and the want of a person capable of repairing it. The errors that might arise from this source were reduced as much as possible by frequent ratings. The same meter was seldom used longer than two weeks without receiving a thorough rating, and when thought advisable it was sent to Saint Louis for repairs. With the greatest precaution it was impossible to keep the meter in perfect order at all times, and consequently the frictional quantity will be found rather large in some of the equations.

Method of rating the meter.—The rating was made in the still water of a pond about 4 feet deep. The meter was attached to an iron rod secured in a vertical position at the bow of a skiff, and immersed to a depth of about 2¼ feet. The skiff, with the meter thus attached, was drawn through the water at a uniform velocity by a man walking or running with even steps, holding a rope attached to the bow. The time and revolutions of the wheel were taken over a distance of 150 feet in most of the ratings. A complete rating consisted of from twelve to twenty such observations, the rate of the skiff varying from three-quarters of a foot to 10 feet per second.

The method of timing in rating was as follows: When practicable, two ranges were laid off at right angles to the path of the skiff and the proper distance apart. On each of these an observer was stationed, who called "time" when the meter rod passed his range. The register and watch readings were taken by the observer in the skiff in accordance with these signals. In many of the ratings this method was not practicable, owing to the irregular shape of the pond. In this case the signals were given on two tags placed on the rope used for drawing the skiff, "time" being called as they passed a certain point.

This method was probably as accurate as the former, as great care was taken to have the rope stretched when the signals were given.

The equations were derived from the results of rating by the method of least squares as furnished from the office.

Vertical velocity curves.—The observations for the vertical velocity curves were always taken at some one of the discharge stations, and in connection with that work. After completing the mid-depth observations at a station, when it was desired to take a vertical curve, the meter was immersed about 6 inches, and an observation of one minute made. It was then lowered successively a distance corresponding to some whole number of turns of the main lowering reel, and one minute's observation made at each point. This was kept up until a point was reached as near the bottom as it was practicable to run the meter. The points in the curves were usually taken from 3 to 5 feet apart. The distance was obtained in feet by taking such a part of the sounding, as the number of turns between points was of the whole number of turns from the surface to the bottom. These observations were made at different discharge stations from day to day, and as these varied in position, there is a complete distribution of the curves across the river, including all depths and velocities.

Transverse velocity curves.—The transverse velocity observations were made on a range located in the first bend above Columbus. The range was above the large eddy on the Kentucky shore, but entered slackwater on that side, at high stages of the river. The observations were made with the meter, run in front of the launch, not at anchor, but held in position with steam. The method was as follows:

The meter, being clamped to its rod and weight as previously described, was suspended by a wire that passed over a pulley in the end of a beam that projected about 6 feet in front of the bow of the launch. The wire passed thence around a reel on the launch, by means of which the meter was raised and lowered. The launch, with the meter thus arranged, was steamed above the range some distance, when the engine was checked and the meter lowered to a position about 6 feet below the surface. The launch was now allowed to drop slowly to line. When the flagman, who was stationed in the bow, reached the range, he called "time." The register was then started and the watch time noted; at the same time the speed of the engine was increased sufficiently to hold the boat on range. After a run of about three minutes, during which time the boat was held as nearly in one position as practicable without anchoring, the flagman was again brought to range. He called "time," and the register was stopped, and its reading, with that of the watch, taken and recorded. The position of the launch was located by a transitman on shore, who took his angles on the flagman at the drop of the flag. His instrument was stationed at the end of a 540-foot base, laid off at right angles to the range. After and including September 11th the angles were taken with a goniometer.

A set of transverse velocity observations consisted of velocities obtained as above at from 30 to 35 points distributed at equal intervals across the river. Soundings were also taken at each station, as the launch drifted across the range, and the shore lines were located in each set of observations.

Longitudinal soundings.—The longitudinal soundings were made over a reach of 500 feet, extending 250 feet above and below the gauging section. A set of observations consisted of from 12 to 15 lines of soundings, made from a floating skiff in the following manner:

The skiff having been set adrift some distance above the upper range of the reach, the leadsman took his position in the bow, and cast his lead in time for the line to become vertical before reaching the range. As soon as "time" was called by the flagman, he commenced sounding at as short intervals as was desired, raising and lowering his lead as much as was required by the irregular contour of the bed of the river. Whenever in his judgment the skiff was drifting too fast or too slow for the lead-line to maintain its vertical position, he called out to the boatman to "hold up" or "back," saying "all right" when the boat was brought to the proper position. The soundings were recorded by an observer in the stern of the skiff, who also noted the time of crossing the ranges.

The skiff was located by a transitman on shore, at 4 points in its path: on the upper and lower ranges, and on two ranges 200 and 300 feet respectively from the upper range. By means of back and front signals on each of the ranges, the flagman signaled to the observer at the transit when the skiff was on line. The angle was taken on the flagman, who sat near the leadsman. From 50 to 150 soundings were taken on each line of 500 feet; sometimes the number was even greater in very low water. Previous to receiving the transit, March 1, the boat was located in only one point of its path, midway between the second and third ranges, by means of the telemeter. After and including September 8 the angles were taken with a goniometer, from the station previously occupied by the transit.

Cross-section soundings.—Frequent soundings were made of a section, located in Beckwith's Bend, 12 miles below Columbus, for the purpose of determining the amount of scour or fill in sharp bends, corresponding to certain changes in the gauge. The soundings were all taken while drifting, either from the launch or a skiff. From 60 to 75 soundings were made at a time, distributed at equal intervals across the river. They were located by a transitman on shore, stationed at the end of a 600-foot base. The angles were taken on a flagman, stationed near the leadsman. There was also a flagman on shore to give range. After the transit was taken away in August, the goniometer was used for taking the angles. It was stationed on a new base line of 1,020 feet in length. In order to ascertain the character of the fill, specimens of the bottom were taken at each sounding by means of a soaped lead.

INSTRUMENTS CONSTRUCTED.

Telemeter.—Previous to March 1 no transit, sextant, or level had been furnished the party. It was therefore necessary to contrive some means by which observation stations could be located. This necessity gave rise to the construction and use of what has been denominated the telemeter. It consisted of a wooden box, having two of its faces parallel trapezoids, two of them inclined rectangles, the remaining two, the ends, being parallel rectangles. The inside dimensions were about as follows: length, 2 feet; cross-section at the smaller end, 2 by 3 inches; cross-section at the larger end, 2 by 10 inches. At the smaller end of the box was an eye-piece, which consisted of a cylindrical block of wood with a small aperture or peep-hole.

In the larger end was a longitudinal opening the full width of the box and about ½ inch in width. It occupied the middle line of the end of the box, and through it distant objects could be seen by looking through the eye-piece. Inside the box was a sliding reticule that contained a pair of fine parallel wires. It was arranged to slide along the central line of the inclosed space and from one end to the other. On top of the reticule was an upright post that moved in an opening in the upper face of the box, and terminated in a rectangular block of wood that moved along on top of the box. This was used as a vernier piece. The top of the box was graduated so that by means of the vernier the instrument could be read to single feet. The graduation was made in the following manner: Two signals were erected at a distance of 50 feet apart. The distance was arbitrarily chosen as the most convenient. From the middle point of the line joining the signals a perpendicular was laid off. On this two points were located, one 400 feet and the other 1,200 feet distant. At each of the points there was made a series of observations to determine the exact location of the 400 and 1,200 foot marks of the graduation on top of the box. In each of these observations the box was held so that the signals could be seen when looking through the peep-hole with the eye conveniently near it. The reticule was then moved, if necessary, by taking hold of the vernier piece on top, until the wires were brought, respectively, in line with the signals. The position of the zero of the vernier was then marked on the box.

The mean of all the observations made in this way was taken as the mark of graduation sought. Having found the 400 and the 1,200-foot marks, the remaining hundred-foot marks were obtained by dividing the space into 8 equal parts. Each of these spaces was subdivided into 10 equal parts for the 10-foot marks.

The graduation for distances less than 400 feet, and greater than 1,200 feet, was made by actual measurement with a scale, the spaces being proportional to the distances. In order to use the telemeter in measuring distances on the river, signals were put up on both shores, at a distance of 50 feet apart. Back signals were erected so that the observer could tell when he was midway between the ranges, that being necessary to perfect accuracy. A slight deviation either way made no appreciable error in long distances. To measure a distance, the observer brought the box to a horizontal position, the wires then being vertical. Placing his eye at the peep-hole, he swung the box, if necessary, until the signals came into the field of view. He then moved the sliding vernier on top of the box, until the wires were brought in line respectively with the signals. Being careful not to move the vernier, he lowered the box sufficiently to read the distance. The instrument was not capable of measuring distances greater than about 1,600 feet with accuracy. For this reason, signals were placed on both shores and measurements made each way. The accuracy with which distances could be measured with the telemeter, depended upon the stability of the observer's position, and the consequent nicety with which the wires could be brought into line with the signals. In windy weather this was somewhat difficult, but great skill was acquired by practice, and a very close approximation could be obtained at all times. Much greater accuracy could be obtained on land, when a stable rest could be had, and it was possible to measure distances accurately to within 3 feet.

Goniometer.—This was a plane table with a revolving alidade, and was arranged for centering by means of a plumb-bob attached beneath the point of revolution. This point was taken as the center of an arc described on the table with a radius of 25 inches. Angles were taken with the goniometer by measuring the chords of the included arcs. The angle corresponding to a measured chord was taken from Gillespie's tables. Any point in the arc could be taken for the zero point, and the chords measured from it. This was a matter of great convenience in setting up the instrument. To measure an angle on a moving object, the eye was brought to the peep-sight and the alidade revolved so as to keep the vertical wire in line with the object. When the signal was given, the motion was stopped, and the intersection of the line of sight with the arc marked with a well sharpened pencil. The chord was then measured with a triangular scale. If the chord was too long for the scale, the included arc was divided into two or more parts, and the sum of the corresponding angles taken. This prevented the use of a ruler being necessary. Under favorable conditions a tolerably close degree of approximation could be attained with the goniometer.

Remarks.—On the 11th of October instructions were received to turn over to my recorder, J. H. Field, all instructions and engineering property, and report at Saint Louis at the earliest convenience for other duties. The remainder of the observations, which were continued till November 25th, were in charge of Mr. Field, who for some time previous had conducted the field-work of the discharge observations.

After the meter came into constant use in March the field-work did not require the full attention of both assistant and recorder. After that date a large part of the assistant's time was occupied in computing discharges and doing other office work. At the time of leaving the work the discharges had been computed up to date, with the exception of about 8 weeks. The remainder of the computations were made in the office under your immediate supervision. At the time of leaving the work none of the notes in connection with velocity curves and cross-section and longitudinal soundings had been reduced, excepting one set of longitudinal soundings, which had been plotted and a tracing made.

The success of the work depended largely upon the ability to make the best use of the means at hand for accomplishing a particular purpose. The more inadequate the means, the greater the dexterity of judgment required.

The most perplexing problems often presented themselves, inasmuch as the magnitude of the work was probably underestimated in the outset. The greatest exertion was made to obtain the best results possible with the methods employed. Much depended upon the individual members of the party, who, with few exceptions, were always prompt and true to duty. They were J. H. Field, recorder; H. A. Wilson, steersman; W. J. Wilder, engineer; John V. Bandy, A. J. Wilder, and John Q. Hamilton, boatmen.

Respectfully submitted.

J. H. DAVIS,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

Discharge Observations, Columbus, Ky.

The discharge computations for this station were made in the field, and by the following method, viz: The cross-sections and positions of velocity observations were plotted on cross-section paper, the cross sections divided into partial sections and their areas determined by counting the squares.

The meter velocities were determined by ratings frequently taken.

Rod float velocities were reduced by Francis' formula. Many of the abrupt changes in area are probably due to change in method of taking observations; a change in method usually resulting in a marked change in the number and position of the cross-section soundings, and often in the values of the soundings themselves. The largest number of soundings were taken in rod-float observations.

The gauge readings on "discharge days" are mean readings for the time occupied in taking observations. On "no discharge days" the noon reading is recorded; noon being about the mean time of field observations.

Datum plane was taken at a gauge reading of 102.627 feet.

Datum width, 2,694 feet.

Datum area 191,880 square feet, as observed on February 28.

Datum areas for other days were determined by successively adding and subtracting scours and fills.

Mean depth was determined by dividing *water area* by *water width*, and datum depth by a similar process.

MISSISSIPPI RIVER.

Discharge observations at Columbus, Ky.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.									
			Water.	Below datum.	Mean.	Mean datum.	Maximum.							
1881.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*			
Dec. 8	80.115	......	......	......	......	......	......	......	......	......	......	......	......	
9	79.085	—1.030	......	......	......	......	......	......	......	......	......	......	......	
10	78.275	—0.810	......	......	......	......	......	......	......	......	......	......	......	
11	77.565	—0.710	......	......	......	......	......	......	......	......	......	......	......	
12	76.940	—0.625	......	......	......	......	......	......	......	......	......	......	......	
13	76.430	—0.510	......	......	......	......	......	......	......	......	......	......	......	
14	76.195	—0.235	......	......	......	......	......	......	......	......	......	......	......	
15	76.090	—0.105	......	......	......	......	......	......	......	......	......	......	......	
16	76.110	+0.020	......	......	......	......	......	......	......	......	......	......	......	
17	76.860	+0.750	126,880	193,467	50.8	71.8	66.4	2,526	......	3.456	436,711.8	VI 1-2	D. F.	
18	78.045	+1.185	......	......	......	......	......	......	......	......	......	......	......	
19	79.490	+1.445	......	......	......	......	......	......	......	......	......	......	......	
20	81.352	+1.862	......	......	......	......	......	......	......	......	......	......	......	
21	83.740	+2.388	140,560	190,206	55.2	71.8	73.8	2,544	—3,261	5.058	711,020.8	XII 1-2	D. F.	
22	85.463	+1.723	143,890	188,642	56.1	70.0	74.4	2,556	—1,564	5.289	758,170.1	V 1-3	D. F.	
23	86.656	+1.193	148,540	190,737	57.9	70.8	76.8	2,566	+2,095	5.548	824,098.8	III-V 3-6	D. F.	
24	87.776	+1.120	153,860	193,178	59.8	71.7	80.8	2,575	+2,441	5.667	872,002.5	VI 1-2	D. F.	
25	89.211	+1.435	......	......	......	......	......	......	......	......	......	......	......	
26	90.931	+1.720	......	......	......	......	......	......	......	......	......	......	......	
27	92.302	+1.371	......	......	......	......	......	......	......	......	......	......	......	
28	93.176	+0.874	172,090	197,846	65.3	73.8	87.2	2,633	+4,168	6.527	1,123,288.5	XI 5-6	D. F.	
29	93.766	+0.590	174,090	197,790	66.0	73.4	87.9	2,641	+ 444	6.100	1,061,997.5	III 8-10	R. F.	
30	94.026	+0.260	173,870	196,882	65.4	72.9	86.9	2,650	—1,408	6.150	1,066,290.6	II-III 6-8	R. F.	
31	93.956	—0.070	176,730	199,928	66.7	74.2	89.5	2,650	+3,546	6.273	1,108,652.5	V 2-8	R. F.	
1882.														
Jan. 1	93.776	—0.180	......	......	......	......	......	......	......	......	......	......	......	
2	93.486	—0.290	......	......	......	......	......	......	......	......	......	......	......	
3	93.296	—0.190	180,170	205,115	68.1	76.1	91.2	2,645	+5,187	5.906	1,064,115.1	VI-VII 1-3	R. F.	
4	93.136	—0.160	......	......	......	......	......	......	......	......	......	......	......	
5	92.950	—0.186	174,540	200,399	66.1	74.4	95.5	2,640	—4,716	5.753	1,004,202.8	VI 1-2	R. F.	
6	92.786	—0.164	172,720	199,012	65.5	73.9	86.1	2,637	—1,387	5.743	991,908.6	Light.	R. F.	
7	92.446	—0.340	......	......	......	......	......	......	......	......	......	......	......	
8	92.196	—0.250	......	......	......	......	......	......	......	......	......	......	......	
9	91.816	—0.380	165,810	194,657	63.0	72.8	88.0	2,632	—4,355	5.467	906,540.0	V-VII 1-3	R. F.	
10	91.796	—0.020	......	......	......	......	......	......	......	......	......	......	......	

MISSISSIPPI RIVER—*Discharge observations at Columbus, Ky.*—Continued.

Date	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.									
			Water.	Below datum.	Mean.	Mean datum.	Maximum.							
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*			
Jan. 11	92.047	+0.251	168,150	196,389	63.8	72.9	89.0	2,633	+1,732	5.649	949,838.2	VI 1-2	R. F.	
12	92.519	+0.472												
13	93.303	+0.784												
14	94.436	+1.133	172,360	194,278	64.8	72.1	91.5	2,659	−2,111	6.302	1,086,202.0	VII 1-2	R. F.	
15	95.492	+1.056												
16	96.190	+0.698												
17	96.900	+0.710	178,900	194,255	67.1	72.1	92.0	2,668	− 23	7.360	1,316,692.6	V-VII 2-5	R. & D. F.	
18	97.436	+0.538	183,410	197,329	68.6	73.2	92.0	2,671	+3,074	7.446	1,365,648.8	VI-VIII 1-3	D. F.	
19	97.934	+0.496	181,610	194,204	68.0	72.1	94.4	2,672	−3,125	7.428	1,348,937.4	VI 2	D. F.	
20	98.304	+0.370	184,840	196,445	70.0	72.9	95.6	2,672	+2,241	7.492	1,384,950.2	XI 2-7	R. F.	
21	98.615	+0.311												
22	98.954	+0.339												
23	99.268	+0.314												
24	99.444	+0.176												
25	99.611	+0.167	179,360	187,459	66.6	69.6	91.5	2,693	−8,986	7.607	1,364,362.8	VI-XI 5-7	R. F.	
26	99.811	+0.200	182,420	189,980	67.8	70.5	95.0	2,694	+2,521	8.018	1,462,661.7	XI 3-6	R. F.	
27	99.881	+0.070	184,560	191,932	68.5	71.2	94.0	2,694	+1,952	7.961	1,469,803.5	VII 1-3	M.	Mid-depth only.
28	100.064	+0.183												
29	100.011	−0.053												
30	99.984	−0.027	183,500	190,594	68.1	70.7	91.0	2,695	−1,338	7.467	1,370,200.9	VII 1-3	M.	Do.
31	100.064	+0.080												
Feb. 1	100.066	+0.002	180,330	187,203	66.9	69.5	91.0	2,695	−3,391	7.614	1,372,945.4	XI 4-6	M. & R. F.	Meter at mid-depth.
2	100.052	−0.014	174,698	181,609	65.1	67.4	83.0	2,695	−5,594	8.053	1,406,911.6	VI 2-3	M.	Do.
3	100.027	−0.025	182,160	189,138	67.5	70.2	90.0	2,697	+7,529	7.398	1,347,585.0	VII-VIII 2-3	R. F.	
4	100.071	+0.044	184,950	191,809	68.6	71.2	89.5	2,697	+2,671	7.725	1,428,752.7	IV-V 6-10	R. F.	
5	99.973	−0.098												
6	99.859	−0.114	182,340	189,771	67.5	70.4	91.2	2,701	−2,088	7.247	1,321,504.6	XI 3-10	R. F.	
7	99.746	−0.113	181,890	189,626	67.4	70.4	87.0	2,699	− 145	7.517	1,366,928.1	XI 3-6	R. F.	
8	99.552	−0.194	190,940	199,199	70.8	73.9	95.0	2,697	+9,573	7.426	1,417,857.2	IV-V 4-6	R. F.	
9	99.343	−0.209	188,970	197,792	70.1	73.4	97.5	2,694	−1,407	7.405	1,399,373.0	V 0-7	R. F.	
10	99.051	−0.292	188,540	198,148	70.1	73.6	93.5	2,689	+ 356	7.035	1,326,303.8	XI 3-7	R. F.	
11	98.712	−0.339	188,510	199,028	70.2	73.9	94.5	2,684	+ 881	6.840	1,289,452.2	X-XI 5-7	R. F.	
12	98.331	−0.381												
13	98.079	−0.252	188,560	200,777	70.3	74.5	95.0	2,682	+1,748	6.594	1,243,445.0	V 3-6	R. F.	
14	98.056	−0.023	185,020	197,299	69.0	73.2	92.5	2,681	−3,478	6.646	1,229,568.3	VII-XII 2-3	R. F.	
15	97.856	−0.200	193,260	206,075	71.9	76.5	94.5	2,680	+8,776	6.485	1,253,863.8	VII-XI 3	R. F.	
16	98.014	+0.158												

	17	98.501	+0.487													
	18	98.739	+0.238	186,900	197,348	69.7	73.3	93.0	2,681	−3,727	6.306	1,272,496.6	VII	3	M.	Do.
	19	98.865	+0.126													
	20	99.071	+0.206													
	21	99.991	+0.920													
	22	101.301	+1.310	197,020	200,589	72.9	74.5	99.5	2,689	+3,241	8.137	1,603,215.4	III	3–4	R. F.	
	23	101.991	+0.690													
	24	102.381	+0.390													
	25	102.666	+0.285													
	26	102.801	+0.135													
	27	102.691	−0.110													
	28	102.627	−0.064	191,880	191,880	71.2	71.2	101.0	2,694	−3,709	8.121	1,558,823.8	VI	3–6	R. F.	
Mar.	1	102.367	−0.260	182,196	182,890	68.4	67.9	100.5	2,640	−3,990	8.241	1,501,527.0	XII	2	R. F.	
	2	102.039	−0.328	189,560	191,123	71.4	70.9	94.0	2,649	+3,233	8.025	1,521,139.6	XII	3	R. F.	
	3	101.878	−0.161	188,880	190,869	71.3	70.8	98.0	2,649	− 254	8.039	1,518,454.4	Calm		R. F.	
	4	101.681	−0.197	180,510	189,021	70.0	70.2	98.0	2,649	−1,848	7.845	1,463,149.5	X	2–4	R. F.	
	5	101.455	−0.226													
	6	101.118	−0.337	186,110	190,114	70.1	70.6	95.5	2,654	+1,093	7.525	1,430,047.8	VI	3–5	R. F.	
	7	100.828	−0.290	184,020	188,793	69.3	70.1	89.5	2,653	−1,321	7.625	1,408,204.8	VI	4–6	R. F.	
	8	100.550	−0.278	180,650	186,159	68.4	69.1	89.5	2,641	−2,684	7.694	1,389,912.2	Calm		R. F.	
	9	100.401	−0.149													
	10	100.219	−0.182	181,830	188,213	68.8	69.9	90.5	2,641	+2,054	7.225	1,323,720.1	VI	3–5	R. F.	
	11	100.052	−0.167	178,620	185,444	67.7	68.8	88.5	2,639	−2,769	7.351	1,313,074.9	I	3–4	R. F.	
	12	100.093	+0.041													
	13	100.188	+0.095	185,130	191,595	70.0	71.1	92.5	2,644	+6,151	7.350	1,360,649.6	V	3–5	R. F.	
	14	100.341	+0.153	185,825	191,885	70.2	71.2	92.5	2,646	+ 290	7.089	1,317,275.1	XI	2–6	R. F.	
	15	100.368	+0.027	185,970	191,959	70.3	71.3	89.0	2,646	+ 74	7.425	1,385,773.7	II	3	R. F.	
	16	100.251	−0.117	185,790	192,069	70.2	71.3	92.0	2,646	+ 130	7.354	1,366,265.7	VI	2	R. F.	
	17	100.089	−0.162	187,640	194,368	70.9	72.1	88.5	2,645	+2,279	7.136	1,338,925.8	X	3–5	R. F.	
	18	99.821	−0.268													
	19	99.601	−0.220													
	20	99.267	−0.334													
	21	98.805	−0.462	182,902	193,020	68.7	71.6	84.0	2,635	−1,348	6.387	1,168,218.0	II	5–10	M.	
	22	98.242	−0.563	187,465	199,066	71.2	73.9	90.0	2,634	+6,046	6.091	1,141,828.0	IV–I	4–6	M.	
	23	97.456	−0.786	182,450	196,120	69.8	72.8	86.0	2,632	−2,946	5.778	1,053,840.3	XI–XII	6–8	M.	
	24	96.789	−0.667	183,225	198,650	69.1	73.7	87.0	2,630	+2,530	5.810	1,064,509.2	VI	3–4	M.	
	25	96.271	−0.518	176,835	193,621	67.3	71.9	82.0	2,627	−5,029	5.462	965,913.3	XI	3–6	M.	
	26	95.938	−0.333													
	27	95.938	−0.000	178,860	196,520	68.1	72.9	82.0	2,625	+2,890	5.596	1,000,966.7	XI–V	5–10	M.	
	28	95.756	−0.182	178,865	197,003	68.1	73.1	82.0	2,624	+ 483	5.433	971,713.0	Calm		M.	
	29	95.796	+0.040	179,800	197,883	68.5	73.4	82.0	2,624	+ 830	5.510	990,702.4	XI	4–10	M.	
	30	95.933	+0.137	180,525	198,198	68.7	73.6	84.0	2,628	+ 365	6.051	1,092,883.0	V–VI	4–7	M.	
	31	96.060	+0.127													
Apr.	1	96.152	+0.092	181,430	198,527	69.0	73.7	86.0	2,630	+ 329	5.900	1,070,393.7	XII–XI	3–4	M.	
	2	96.076	−0.076													
	3	95.889	−0.187	180,895	198,684	68.7	73.7	86.0	2,631	+ 157	5.941	1,074,721.6	XII	2	M.	
	4	95.342	−0.547	178,565	197,792	68.0	73.4	86.0	2,628	− 892	5.753	1,027,339.3		2	M.	
	5	94.386	−0.956	177,690	199,428	67.7	74.0	85.0	2,625	+1,636	5.491	975,641.7	XI	2	M.	
	6	92.940	−1.446	172,260	197,789	65.8	73.4	84.0	2,619	−1,630	5.220	899,116.8	XII	3–4	M.	
	7	91.076	−1.864													
	8	89.636	−1.440	162,480	196,618	62.7	73.0	79.0	2,589	−1,176	4.756	772,834.2	XII	2	M.	
	9	89.382	−0.254													

MISSISSIPPI RIVER—*Discharge observations at Columbus, Ky.*—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.									
			Water.	Below datum.	Mean.	Mean datum.	Maximum.							
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*			
Apr. 10	89.831	+0.449	164,320	197,948	63.5	73.5	81.0	2,589	+1,335	4.886	802,801.8	IV-VI 5-8	M.	
11	89.928	+0.097	164,030	197,407	63.3	73.3	80.0	2,590	— 541	4.835	793,126.9	VI 4-6	M.	
12	89.941	+0.013	164,740	198,083	63.6	73.5	81.0	2,590	+ 676	4.936	813,159.1	VI 7-10	M.	
13	89.661	—0.280	164,880	198,948	63.7	73.8	80.0	2,590	+ 865	4.768	786,127.7	V 4-6	M.	
14	89.401	—0.260	162,890	197,631	63.0	73.4	80.0	2,590	—1,317	4.742	772,397.2	VI 3-5	M.	
15	89.386	—0.015	162,910	197,690	63.0	73.4	80.0	2,590	+ 59	4.782	778,956.6	VI 2-3	M.	
16	89.626	+0.240												
17	89.946	+0.320	162,335	195,665	62.7	72.6	80.0	2,590	—2,025	4.895	794,628.5	VIII-XI 2-3	M.	
18	89.891	—0.055	163,590	197,063	63.0	73.1	80.0	2,595	+1,398	4.948	809,523.0	VIII-XII 2-3	M.	
19	89.407	-0.484	160,890	195,618	62.1	72.6	77.5	2,591	—1,445	4.406	708,952.0	II 8-10	R. F.	
20	88.545	—0.862	156,980	193,936	60.9	72.0	75.0	2,578	—1,682	4.430	695,463.4	XII 2	R. F.	
21	87.546	—0.909	154,320	193,847	60.0	72.0	78.0	2,570	— 89	4.588	708,066.5	XI 5-6	M.	
22	86.757	—0.789	152,090	193,640	59.5	71.9	79.0	2,558	— 207	4.316	656,377.4	XI 2-4	M.	
23	85.841	—0.916												
24	85.321	—0.520	148,700	193,909	58.6	72.0	74.0	2,538	+ 269	4.307	640,451.8	Calm	M.	
25	85.291	—0.030	150,760	196,045	59.4	72.8	75.0	2,538	+2,136	4.367	658,422.2	Calm	M.	
26	85.723	+0.432	151,870	196,058	59.8	72.8	74.0	2,540	+ 13	4.199	637,731.7	XII 5-8	M.	
27	86.101	+0.378	150,955	194,184	59.1	72.1	75.0	2,558	—1,878	4.152	626,716.0	VI 3-5	M.	
28	86.601	+0.500											M.	
29	86.936	+0.335	153,630	194,722	60.1	72.8	74.5	2,557	+ 542	4.192	644,019.4	VI 6-7	R. F.	
30	87.186	+0.250												
May. 1	87.411	+0.225	153,580	193,405	59.8	71.8	74.1	2,566	—1,317	4.802	660,526.5	XII 3	R. F.	
2	87.608	+0.197	154,840	194,209	60.3	72.1	76.0	2,568	+ 804	4.619	715,162,2	VI 2-5	M.	
3	87.676	+0.068	154,610	193,804	60.2	71.9	77.0	2,570	— 405	4.496	695,135.4	XI 2-3	M.	
4	87.710	+0.034	158,900	198,007	61.7	73.4	76.0	2,575	+4,203	4.563	724,982.9	XI 2-5	M.	
5	87.505	—0.205	156,780	196,414	61.0	72.9	76.0	2,572	—1,593	4.434	695,155.8	XI 4-8	M.	
6	87.211	—0.294	153,840	194,229	59.9	72.1	77.0	2,568	—2,185	4.543	698,859.3	XI 2-3	M.	
7	86.766	—0.445												
8	86.310	—0.456	148,520	191,221	57.9	71.0	74.0	2,565	—3,008	3.882	576,578.9	X-XII 1-3	M.	
9	87.473	+1.163	159,750	190,456	61.8	74.0	76.0	2,585	+8,235	4.770	762,130.2	XI 1-3	M.	Mid-depth only.
10	90.516	+3.043	161,040	192,809	62.1	71.6	78.0	2,592	—6,567	5.319	856,651.8	I-II 2-4	M.	
11	92.486	+1.970	170,612	197,324	65.6	73.2	81.5	2,603	+4,455	4.988	850,935.6	I 4-6	R. F.	
12	94.114	+1.628	171,660	194,120	65.8	72.1	87.0	2,609	—3,195	5.402	927,554.0	V 5-10	R. F.	
13	95.481	+1.367	181,050	199,942	69.0	74.2	90.0	2,624	+5,818	5.547	1,004,211.9	VI 6-8	R. F.	
14	96.076	+0.595												
15	96.156	+0.080	181,110	198,280	69.0	73.6	87.5	2,627	—1,712	5.793	1,049,187,2	VI 3-5	R. F.	
16	96.172	+0.016	181,480	198,508	69.1	73.7	88.5	2,627	+ 278	5.737	1,040,778.3	VI 2-3	R. F.	

	17	96.146	−0.026	181,720	198,866	69.2	73.8	88.0	2,627	+ 358	5.567	1,011,718.6	Calm	.....	R. F.	
	18	96.046	−0.100	175,500	192,909	66.7	71.6	86.5	2,632	−5,957	5.693	999,140.7	VI	2	R. F.	
	19	96.129	+0.083	178,250	195,441	67.6	72.5	86.0	2,635	+2,532	5.839	1,040,760.8	XII	1–3	M.	
	20	96.146	+0.017	174,750	191,896	66.8	71.2	85.0	2,635	−3,545	5.850	1,022,836.7	XI-XII	1–3	M.	Do.
	21	96.411	+0.265													
	22	96.649	+0.238	180,130	195,950	68.3	72.7	88.0	2,636	+4,054	6.050	1,069,851.6	V-VI	3–6	M.	
	23	96.681	+0.032	179,060	194,796	67.9	72.8	85.0	2,636	−1,154	6.207	1,111,465.2	XI	1–3	M.	Do.
	24	96.395	−0.286													
	25	95.854	−0.541	178,090	196,006	67.6	72.8	84.0	2,635	+1,210	5.908	1,052,080.2	IV-VII	2–4	M.	
	26	95.053	−0.801	174,990	195,015	66.5	72.4	84.0	2,632	− 991	5.602	980,226.1	XII	1–2	M.	
	27	93.916	−1.137	171,020	194,031	65.2	72.0	81.0	2,621	− 984	5.249	897,091.1	XII	1–2	M.	
	28	93.001	−0.915													
	29	92.285	−0.716	169,680	196,959	64.9	73.1	81.0	2,613	+2,928	5.204	882,965.9	VI	2	M.	
	30	92.286	+0.001	168,090	195,366	64.8	72.5	81.0	2,613	−1,593	5.331	896,046.1	IX-XII	2–4	M.	Do.
	31	93.312	+1.026	172,510	197,104	66.0	73.2	84.0	2,616	+1,738	5.532	954,398.6	XII-I	3–6	M.	Do.
June	1	94.199	+0.887	174,710	196,979	66.5	73.1	86.0	2,626	− 125	5.784	1,010,529.4	V-VII	2–4	M.	
	2	94.951	+0.752	175,450	195,742	66.0	72.7	84.0	2,632	−1,237	5.934	1,041,069.5	X-XII	4–8	M.	
	3	95.525	+0.574	180,610	199,390	68.5	74.0	87.0	2,635	+3,648	5.929	1,070,903.9	I-IV	3–6	M.	
	4	95.980	+0.455													
	5	96.236	+0.256	178,450	195,856	67.6	72.5	86.0	2,637	−4,034	6.159	1,099,027.8	III-IV	2–3	M.	
	6	96.371	+0.135					88.6	2,627				XII	2–3	R. F.	
	7	96.335	−0.036	179,770	196,416	68.4	72.9	86.5	2,627	+1,060	5.468	983,061.7	XII	2–3	R. F.	
	8	96.324	−0.011	179,890	196,565	68.5	73.0	85.5	2,627	+ 149	5.483	986,329.8	XII	2	R. F.	
	9	96.111	−0.213	178,460	195,695	67.9	72.6	86.0	2,627	− 870	5.489	979,648.7	XII	2–3	R. F.	
	10	95.678	−0.433	176,080	194,451	67.1	72.2	80.0	2,622	−1,244	5.667	998,766.4	X-XII	2–3	M.	
	11	95.023	−0.655													
	12	94.228	−0.795	169,640	191,813	65.1	71.2	82.5	2,622	−2,638	5.089	863,363.2	I-II	2–3	R. F.	
	13	93.220	−1.008	170,630	195,435	65.6	72.5		2,600	+3,622	4.942	843,249.2	X-XII	2–4	R. F. & M.	
	14	91.924	−1.296	168,270	196,441	64.9	72.9	80.0	2,598	+1,006	4.603	774,626.5	X-XI	4–6	R. F.	
	15	90.224	−1.700	162,150	194,722	62.8	72.3	78.5	2,584	−1,719	4.380	710,277.9	I-II	2–3	R. F.	
	16	88.955	−1.269	158,990	194,839	61.6	72.3	76.5	2,580	+ 117	4.209	669,270.5	II	1–3	R. F.	
	17	88.083	−0.872	156,040	194,132	60.8	72.1	76.0	2,564	− 707	4.124	643,563.0	X	3–4	R. F.	
	18	88.077	−0.006													
	19	89.252	+1.175	157,080	196,099	60.8	72.8	79.0	2,579	+1,967	4.759	747,593.4	V	3–5	R. F.	
	20	91.096	+1.844	163,180	197,433	63.0	73.3	81.5	2,589	+1,334	4.937	805,606.7	X	1–2	R. F.	
	21	92.356	+1.260	166,240	197,225	64.0	73.2	80.8	2,598	− 208	4.955	823,667.2	XII	2	R. F.	
	22	92.882	+0.526	168,150	197,767	64.5	73.4	81.5	2,604	+ 542	4.947	831,867.1	XII	1–2	R. F.	
	23	93.241	+0.359	168,780	197,462	64.8	73.3	83.0	2,605	− 305	5.385	908,860.9	VIII-XII	2	M.	
	24	93.487	+0.246	166,920	194,961	64.1	72.4	83.0	2,605	−2,501	5.392	900,001.1	X-XII	2–4	M.	Mid-depth only.
	25	93.481	−0.006													
	26	93.249	−0.232													
	27	92.784	−0.465	164,840	194,712	63.8	72.3	83.0	2,604	− 249	4.975	820,010.2	VII-X	2–3	M. & R. F.	
	28	91.968	−0.816	166,900	198,982	64.4	73.9	85.0	2,593	+4,270	5.145	859,207.7	VI	2	M.	Do.
	29	91.378	−0.590	162,990	196,509	63.1	72.9	83.0	2,585	−2,473	4.888	796,650.2	II-VI	1–3	M.	
	30	90.818	−0.560	159,250	194,315	61.7	72.1	83.0	2,580	−2,194	4.823	768,490.1	II-XI	2–5	M.	Do.
July.	1	90.751	−0.067	162,540	197,678	63.0	73.4	83.0	2,580	+3,363	4.935	802,201.7	I-XII	2–5	M.	
	2	91.067	+0.316													
	3	91.192	+0.125	162,420	196,419	63.0	72.9	80.0	2,585	−1,259	5.049	820,058.8	XI-I	1–5	M.	
	4	91.876	+0.684													
	5	92.469	+0.593	170,880	201,521	65.8	74.8	82.0	2,596	+5,102	4.847	826,023.7	III-V	2–4	M.	
	6	93.058	+0.589	169,910	199,070	65.3	73.9	86.0	2,601	−2,451	5.051	858,239.2	IX-XI	2–4	M.	
	7	93.625	+0.567	171,300	198,985	65.7	73.9	84.5	2,601	− 85	5.388	922,963.1	X-XII	4–8	M.	

MISSISSIPPI RIVER—*Discharge observations at Columbus, Ky.*—Continued.

Date.		Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Method.	Remarks.
		Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.									
				Water.	Below datum.	Mean.	Mean datum.	Maximum.							
1882.		*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*			
July	8	93.962	+0.337	168,420	195,227	64.2	72.5	86.0	2,608	—3,758	5.332	898,043.6	X-XII 6-8	M.	
	9	94.031	+0.069												
	10	93.788	—0.243	166,170	193,430	63.8	71.8	82.0	2,602	—1,797	5.364	891,366.9	VI-XII 2-10	M.	
	11	93.502	—0.286	167,340	195,344	64.4	72.5	85.0	2,600	+1,914	5.374	899,314.7	V-VII 2-3	M.	
	12	92.932	—0.570	168,470	197,956	64.8	73.5	84.0	2,599	+2,612	5.319	896,212.1	III-VII 3-4	M.	
	13	92.075	—0.857	160,600	192,311	61.9	71.4	82.0	2,593	—5,645	5.083	816,372.2	III-IV 2-3	M.	
	14	90.883	—1.192	160,750	195,545	62.2	72.6	80.0	2,582	+3,234	4.861	781,471.5	IV-VII 1-2	M.	
	15	89.885	—0.998	158,210	195,580	61.3	72.6	78.5	2,579	+ 85	4.708	759,111.7	X-XII 1-2	M.	
	16	89.857	—0.028												
	17	88.083	—1.774	152,310	194,303	59.7	72.1	78.0	2,552	—1,277	4.531	690,109.5	VI 1-2	M.	
	18	87.482	—0.601	150,050	193,572	59.2	71.9	78.0	2,536	— 731	4.312	647,014.9	XII 2-3	M.	
	19	86.716	—0.766	146,690	192,151	58.5	71.3	76.0	2,527	—1,421	4.334	635,797.1	VI 1-2	M.	
	20	86.052	—0.664	147,160	194,296	58.4	72.1	77.0	2,519	+2,145	4.087	601,476.0	VI 1-2	M.	
	21	85.406	—0.646	143,100	191,858	57.2	71.2	74.5	2,503	—2,438	3.994	571,521.0	III-VI 1-3	M.	
	22	85.095	—0.311	146,620	196,156	58.5	72.8	76.0	2,497	+4,298	3.946	578,571.8	V-VI 3-5	M.	
	23	84.644	—0.451												
	24	83.898	—0.746	138,060	190,581	55.4	70.7	73.0	2,491	—5,575	3.832	529,106.9	VI 2	M.	
	25	83.178	—0.720	138,360	192,672	55.7	71.5	72.0	2,484	+2,091	3.089	510,412.9	VI 2	M.	
	26	82.082	—1.096	134,710	191,741	54.4	71.2	71.0	2,477	— 931	3.555	478,828.6	XII 2	M.	
	27	80.981	—1.101	130,510	190,259	53.0	70.6	71.0	2,461	—1,482	3.266	426,242.9	2	M.	
	28	80.083	—0.898	129,400	191,359	52.6	71.0	68.5	2,460	+1,100	3.229	417,822.2	IX-XII 2-4	M.	
	29	79.419	—0.664	126,570	190,161	51.6	70.6	68.0	2,455	—1,198	3.099	392,246.1	IX-XII 1-2	M.	
	30	78.870	—0.549	121,950	186,889	49.6	69.4	66.0	2,457	—3,272	2.967	361,868.5	IX-XII 2-4	M. & R. F.	
	31	78.326	—0.544						2,467				XII 3-5	R. F.	
Aug.	1	78.122	—0.204												
	2	77.724	—0.398	125,660	193,415	51.1	71.8	65.5	2,457	+6,526	2.568	322,724.7	XII 2-4	R. F.	
	3	77.499	—0.225	127,110	195,418	51.7	72.5	65.5	2,456	+2,008	2.539	322,725.9	1-2	R. F.	
	4	77.205	—0.294	122,620	191,651	49.8	71.1	64.2	2,462	—3,767	2.480	304,085.4	1-2	R. F.	
	5	77.233	+0.028	123,280	192,242	50.1	71.4	64.2	2,461	+ 591	2.566	316,368.8	XII 1-2	R. F.	
	6	78.074	+0.841												
	7	79.006	+0.932	137,090	201,685	55.6	74.9	72.0	2,464	+9,448	3.052	418,441.8	XI-I 3-4	M.	
	8	79.582	+0.576	133,610	196,785	54.2	73.0	72.5	2,466	—4,900	3.143	410,878.1	V-XI 3-8	M.	Do.
	9	79.717	+0.135	137,410	200,252	55.6	74.3	72.0	2,470	+3,467	3.215	441,761.8	III-VI 2-4	M.	
	10	79.438	—0.279	133,040	196,571	53.9	73.0	70.5	2,468	—3,681	3.141	417,820.7	V-VII 3-5	M.	
	11	79.185	—0.253	131,540	195,695	53.4	72.6	71.5	2,464	— 876	3.071	403,976.7	1	M.	Do.
	12	78.987	—0.198	133,830	198,473	55.8	73.7	69.5	2,462	+2,778	3.001	401,684.6	XII 2	M.	
	13	78.732	—0.255												

	14	78.414	−0.468	127,240	193,293	51.8	71.7	69.0	2,456	−5,181	2.969	377,742.2	X-I	3-6	M.	
	15	77.946	−0.468	125,450	192,650	51.2	71.5	68.0	2,451	− 642	2.914	365,576.6	XI-I	4-6	M.	
	16	77.652	−0.294	126,050	194,870	51.9	72.3	68.0	2,447	+2,220	2.822	358,189.5	XII-II	3-6	M.	
	17	77.383	−0.269	126,740	195,318	51.8	72.5	66.0	2,446	+ 448	2.755	349,175.1	IV-VI	3-5	M.	
	18	77.174	−0.209	125,170	194,259	51.1	72.1	68.0	*2,447	−1,059	2.702	338,175.4	VI	3-4	M.	*Caving bank.
	19	76.921	−0.253	122,250	191,939	50.0	71.3	66.0	*2,451	−2,300	2.714	331,859.4	VI	4-6	M.	
	20	76.551	−0.370													
	21	76.249	−0.302	121,670	193,025	49.7	71.6	67.5	2,447	+1,066	2.593	315,523.0	XII	2	M.	
	22	75.695	−0.554	122,920	195,632	50.1	72.6	65.0	2,451	+2,607	2.263	278,122.4		1	R. F.	
	23	75.268	−0.427	122,380	196,137	50.1	72.8	67.0	2,442	+ 505	2.488	304,462.3	XII	2-3	M.	
	24	74.689	−0.579	121,840	197,010	49.9	73.1	66.0	2,440	+ 873	2.300	280,206.0	IX-II	1-3	M.	
	25	74.045	−0.644	119,100	195,841	46.7	72.7	65.0	2,440	−1,169	2.313	275,496.9	IV-I	1-2	M.	
	26	73.572	−0.473	116,916	194,811	48.0	72.3	64.5	2,438	−1,030	2.234	261,289.2		1-2	M.	
	27	73.097	−0.475													
	28	72.848	−0.249	115,980	196,638	47.7	72.6	65.0	2,433	+ 827	2.144	248,660.8	III-VI	3	M.	
	29	72.572	−0.276	115,080	195,409	47.4	72.5	63.8	2,430	− 229	1.904	219,123.8	VII-X	1-4	R. F.	
	30	72.354	−0.218	115,490	196,349	47.5	72.9	63.5	2,428	+ 940	1.871	216,024.9		1	R. F.	
	31	72.361	+0.007	113,800	194,642	46.8	72.2	62.0	2,428	−1,707	2.124	241,689.4	V-VI	1-3	M.	
Sept.	1	72.354	−0.007	117,180	193,039	48.2	73.5	63.0	2,432	+3,397	2.063	241,703.9	VIII-X	2-3	M.	
	2	72.564	+0.210	115,760	196,108	47.5	72.8	64.0	2,433	−1,931	2.150	248,837.4	III-V	3-4	M.	
	3	72.722	+0.158													
	4	72.844	+0.122	113,130	192,796	46.4	71.6	63.5	2,440	−3,312	2.246	254,074.8	V-VII	3-4	M.	
	5	72.987	+0.143	115,590	194,907	47.4	72.3	64.0	2,440	+2,111	2.192	258,412.9	V-VI	3-4	M.	
	6	73.114	+0.127	116,220	195,227	47.6	72.5	64.5	2,441	+ 820	2.129	247,480.9	V-VI	2-4	M.	Mid-depth only.
	7	73.404	+0.290	115,800	194,099	47.4	72.0	64.0	2,443	−1,128	2.068	239,471.2	XI-I	2-4	M.	
	8	73.689	+0.285	117,580	195,183	48.0	72.5	65.0	2,443	+1,084	2.243	263,716.8		1	M.	
	9	73.849	+0.160	116,230	193,442	47.6	71.8	65.0	2,443	−1,741	2.295	266,755.2	V-VI	2-5	M.	
	10	73.754	−0.095													
	11	73.565	−0.189	117,270	195,176	48.0	72.4	63.0	2,441	+1,734	2.227	261,165.1	IV-VI	3-4	M.	
	12	73.256	−0.309	121,330	199,990	49.7	74.2	63.2	2,440	+4,814	1.927	233,767.8	X-XI	2-4	R. F.	
	13	72.993	−0.263	115,320	194,621	47.8	72.2	63.0	2,438	−5,369	2.127	245,312.6	XII	10-15	M.	
	14	72.544	−0.449	111,780	192,175	45.9	71.3	63.0	2,435	−2,446	2.073	231,768.7	XII-III	3-4	M.	
	15	72.297	−0.247	112,080	193,076	46.1	71.7	62.0	2,433	+ 001	2.045	229,250.4	Calm		M.	
	16	72.051	−0.246	112,180	193,774	46.2	71.9	62.0	2,429	+ 698	2.089	234,325.7	XI-I	2-3	M.	
	17	72.606	+0.555													
	18	73.785	+1.179	118,710	196,084	48.7	72.8	64.0	2,439	+2,810	2.348	278,773.2	XI-XII	3-5	M.	
	19	74.733	+0.948	118,350	193,410	48.5	71.8	64.2	2,442	−2,674	2.228	263,628.4	XI-XII	3-5	R. F.	
	20	75.555	+0.822	122,030	195,078	49.7	72.4	66.0	2,454	+1,668	2.647	322,973.3		1	M.	
	21	75.839	+0.284	121,070	193,421	49.3	71.8	67.0	2,455	−1,657	2.651	320,968.7	IV-VI	4-6	M.	
	22	75.319	−0.520	121,580	195,206	49.6	72.5	65.5	2,450	+1,785	2.512	305,395.3	IV-VI	1-3	M.	
	23	74.322	−0.997	118,830	194,896	48.6	72.3	65.5	2,445	− 310	2.346	278,771.3	III-VI	1-3	M.	Do.
	24	73.664	−0.658													
	25	72.962	−0.702	115,250	194,634	47.3	72.2	63.5	2,435	− 262	2.237	257,810.4	IV-VIII	2-6	M.	
	26	72.142	−0.820	112,360	193,738	46.2	71.9	62.0	2,429	− 396	2.167	243,539.2	VI	3-4	M.	
	27	71.361	−0.781	112,850	196,123	46.5	72.8	62.0	2,425	+2,385	2.034	229,489.7	VI	1-2	M.	
	28	70.521	−0.840	110,440	195,749	45.6	72.7	61.0	2,423	− 374	1.969	217,477.6	XI-XII	3-5	M.	
	29	69.959	−0.562	108,040	194,710	44.6	72.3	60.0	2,421	−1,039	1.899	205,211.7	XI-XII	2-4	M.	
	30	69.675	−0.284	105,480	192,837	43.6	71.6	59.0	2,420	−1,873	1.828	192,780.4	XI-XII	3	M.	
Oct.	1	69.201	−0.474													
	2	68.875	−0.326	104,302	193,594	43.1	71.9	59.0	2,417	+ 757	1.782	185,869.7		1	M.	
	3	68.697	−0.178	103,665	193,387	42.4	71.8	58.0	2,417	− 207	1.829	189,644.9		1	M.	
	4	68.812	+0.115	104,670	194,114	43.3	72.1	58.0	2,415	+ 727	1.548	162,053.9		1	R. F.	

MISSISSIPPI RIVER—*Discharge observations at Columbus, Ky.*—Continued.

Date.		Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.		Method.	Remarks.
		Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth,										
				Water.	Below datum.	Mean.	Mean datum.	Maximum.								
1881.		*Feet.*	*Feet.*	*Sq. feet*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*				
Oct.	5	68.915	+0.103	104,150	193,345	42.9	71.8	58.5	2.416	− 769	1.499	156,145.0		1	R. F.	
	6	68.950	+0.035	104,340	193,450	43.1	69.8	58.0	2,419	+ 105	1.877	195,809.9	X-XI	2-4	M.	
	7	68.799	−0 151	105,127	194,602	41.8	72.2	59.0	2,418	+1,152	1.902	199,960.8	I-XI	3-5	M.	
	8	68.676	−0.123													
	9	68.615	−0.061	103,595	193,515	42.8	71.8	59.0	2,418	−1,087	1.801	186,592.0		1	M.	
	10	68.636	+0.021	103,965	193,834	43.0	72.0	59.0	2,418	+ 319	1.812	188,353.5	II-XI	3-4	M.	
	11	68 624	−0.012	102,650	192,548	42.4	71.5	59.0	2,418	−1,286	1.866	191,541.1	VI	2-3	M.	
	12	68.649	+0.025	103,005	192,843	42.6	71.6	59.0	2,418	+ 295	1.963	202,230.1	X-XI	3	M.	
	13	68.419	−0.230	102,915	193,309	42.5	71.8	59.0	2,417	+ 466	1.868	192,252.9	III-IV	4-5	M.	
	14	68.222	−0.197	100,455	191,325	41.5	71.0	57.0	2,416	−1,984	1.869	187,007.8	VII-IX	1-2	M.	
	15	67.958	−0.264													
	16	67.732	−0.226	98,550	190,603	40.9	70.8	57.5	2,411	− 722	1.821	179,496.3	X-XIII	3-5	M.	
	17	67.621	−0.111	99,965	192,285	41.5	71.4	58.0	2,407	+1,682	1.854	185,302.9	IV	4-5	M.	
	18	67.517	−0.104													
	19	67.356	−0.161	97,425	190,383	40.5	70.7	57.0	2,406	−1,902	1.842	179,431.9	V	5	M.	
	20	67.263	−0.093	99,630	192,812	41.4	71.6	57.0	2,406	+2,429	1.769	176,294.0	VI	3-4	M.	
	21	67.331	+0.068	100,075	193,093	41.6	71.7	57.0	2,406	+ 281	1.795	179,608.2	VII-VIII	2-3	M.	
	22	67.623	+0.292													
	23	67.887	+0.264	101,580	193,256	42.0	71.7	58 0	2,421	+ 163	1.875	190,468.9	IV-VI	2-3	M.	
	24	68.023	+0.136	101,660	193,007	41.9	71.6	58.0	2,423	− 249	1.929	196,136.0		1	M.	
	25	68.021	−0.002													
	26	67.961	−0.060	101,115	192,612	41.7	71.5	58.0	2,424	− 395	1.862	188,243.8	XII	3	M.	
	27	67.966	+0.005	103,610	195,095	42.7	72.4	58.0	2,425	+2,483	1.848	191,451.4	XII	5	M.	
	28	68.055	+0.089	100,840	192,109	41.6	71.3	58.0	2,425	−2,986	1.932	194,845.1	X-XII	4-10	M.	
	29	68.205	+0.153													
	30	68.328	+0.120	103,370	193,977	42.6	72.0	58.0	2,426	+1,868	1.959	202,458.5	XI-I	10-15	M.	
	31	68.316	−0.012	99,790	190,426	41.2	70.7	59.0	2,424	−3,551	1.924	192,031.4	XI-XII	1-2	M.	
Nov.	1	68.391	+0.075	101,295	191,749	41.8	71.2	58.5	2,424	+1,823	1.898	192,280.1	X-XII	3-4	M.	
	2	68.557	+0.166	104,570	194,622	43.1	72.2	58.0	2,425	+2,873	1.881	196,715.3	V-VI	3-5	M.	
	3	68.729	+0.172	103,355	192,990	42.6	71.6	59.0	2,426	−1,632	2.007	207,441.9	IV-VI	2-3	M.	
	4	68.821	+0.092												M.	Do.
	5	68.823	+0.002	97,235	186,642	40.1	69.3	57.0	2,426	−6,348	1.925	187,221.4	XI-XII	4-5	M.	Do.
	6	68.808	−0.015	102,340	191,783	42.2	71.2	59.0	2,426	+5,141	1.989	203,553.4	XI-XII	10-15	M.	
	7	68.735	−0.078	104,240	193,860	43.0	72.0	59.0	2,426	+2,077	1.959	204,215.3	XII	3	M.	
	8	68.773	+0.038	102,600	192,028	42.3	71.3	58.0	2,426	−1,832	1.974	202,322.2	XI-I	5-6	M.	
	9	69.051	+0.278	104,000	192,854	42.9	71.6	59.0	2,426	+ 826	1.955	203,314.4	XII	10-15	M.	
	10	69.561	+0.510	104,425	192,041	43.0	71.3	60.0	2,429	− 813	1.927	201,244.0	XI-XII	10-20	M.	

11	69.752	+0.191	104,296	191,492	42.9	71.1	59.5	2,481	− 549	2.120	221,182.2	XI-XII	15	M.	
12	69.861	+0.109													
13	70.881	+0.520	105,820	191,487	43.5	71.1	60.0	2,435	− 5	2.140	226,496.0	III-IV	3	M.	Do.
14	70.656	+9.275	106,450	191,447	43.7	71.1	60.0	2,438	− 40	2.287	243,421.8	XI-XII	10-25	M.	
15	70.471	−0.185	105,695	191,143	43.4	71.0	61.0	2,438	− 304	2.255	238,307.7		1	M.	
16	70.572	+0.101													
17	70.840	+0.268	108,145	192,693	44.3	71.5	60.0	2,440	+1,530	2.266	245,057.5	IV	3-4	M.	
18	70.944	+0.104	107,195	191,489	43.9	71.1	61.5	2,440	−1,204	2.278	244,154.3	IV-V	4-5	M.	
19	70.830	−0.114													
20	70.596	−0.234	106,330	191,473	43.6	71.1	61.0	2,438	− 16	2.255	239,811.0	VI	5-8	M.	
21	70.346	−0.250	107,740	193,405	43.9	71.8	60.0	2.453	+2,022	1.759	189,537.2	Calm	......	R. F.	
22	70.121	−0.225	104,240	190,547	42.5	70.7	59.6	2,455	−2,918	1.806	188,250.8	X	2-3	R. F.	
23	70.039	−0.082	107,640	194,148	43.9	72.1	59.9	2,432	+3,601	1.867	200,980.4	III-IV	6	R. F.	
24	69.891	−0.148	105,250	192,120	43.1	71.8	59.8	2,442	−2,028	1.883	198,215.9	VI	2-8	R. F.	
25	69.838	−0.053	105,365	192,344	43.8	71.4	59.5	2,432	+ 224	1.802	189,694.1	IX-X	3	R. F.	

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., July 16, 1883.

SIR: In accordance with your letter of April 26 inclosing a copy of a letter from the president of the River Commission, I have the honor to submit the following report as an appendix to my report on the Columbus observations:

The information requested was an opinion as to the relative accuracy, reliabililty, and economy of the methods of gauging by double floats, by a vertical rod, and by a meter, with suggestions as to improvements in the methods used.

Relative accuracy.—This part of the subject will be considered by first pointing out some of the sources of inaccuracy in the different methods, and then drawing some conclusions as to the adaptability of each to certain conditions.

I. Method by double floats. There are two probable sources of error in this method: first, the necessity of assuming the mean velocity in a vertical plane at some fixed depth, corrected, perhaps, by some given formula; and, second, the possible inability to measure the velocity correctly at the assumed depth.

(1) By an examination of observations made on velocities in a vertical plane, it is found that there is no fixed relation between the velocities at different depths. This is especially the case in silt-bearing streams, such as the Lower Mississippi, where the conditions are so numerous and unstable. Any method of determining a mean velocity in a vertical plane must therefore provide for measuring it in a great number of points in that plane, if perfect accuracy be desired. The double-float method, which provides for measuring the velocity in but one point in the vertical, can lay little claim to accuracy, when viewed from a theoretical standpoint. It is believed that the results, if closely examined, will also fall behind when viewed from a practical standpoint. The experiments made with the meter, in determining vertical curves, will, when reduced, furnish additional information on this subject. It is believed that they will show material variations from day to day in the relative velocities in a vertical plane, especially where bottom changes are going on. If so, no method can be relied on for perfect accuracy that takes into account only a small part of the vertical section.

(2) There is also some doubt as to the accuracy with which a velocity at any particular depth can be measured by the double-float method. During the observations made at Fulton, Tenn., by Assistant W. H. Powless, it was my duty for several months to give personal attention to the manipulation of the floats. It gave an excellent opportunity for observing their movements in water. I was led to believe that at times the surface and subsurface parts were acted upon by almost opposite forces. At times the surface float would be suddenly drawn to right or left, in which case it would be considerably inclined and partially immersed. Sometimes it would incline backward or forward. In each of these cases the surface float had a powerful influence in retarding or accelerating the sub-float, the velocity of the former not representing the correct velocity of the water in the vicinity of the latter. The above indications were frequently noticeable in high water. Sometimes also in high water the subfloat was apparently held up, the assumed immersion not being reached. This was shown by the fact that several feet of wire were sometimes taken in before there was any appreciable weight of the subfloat. By an examination of the vertical velocity observations at Fulton, Tenn., it will be found that in the sets in which two or more floats were run at the same depth the velocities differ from 1 to 15 per cent.

In these observations the boat was anchored, and the floats all started from the same point, their paths varying but slightly across the ranges. The Fulton observations have been selected, inasmuch as they are probably the best that have been made with double floats on the Mississippi River

II. Method by rod-floats. Within certain limits of depth the vertical rod is well adapted to measuring the mean velocity accurately, being acted upon by the whole body of water in a vertical plane. Where the float can be run of sufficient length to nearly touch bottom, there is but a small source of error due to the corrections to be made. Where due care is taken in the manipulation, allowing full time for the float to acquire a uniform movement and erect position before entering upon its measured path, little variation should be expected from a series of observations in the same plane. A very small per cent. of variation was found in the observations made with the plant at Grafton, Ill., where six rods of the same length were run from each station. As to the two methods of locating instrumentally, and obtaining the length of path by the plant, used on the Upper Mississippi, the latter is preferable where the depth does not exceed about 25 feet; beyond that depth there is difficulty in putting out the float so as to acquire its equilibrium before entering upon the measured path. A rod-float of more than 35 or 40 feet in length can not be handled successfully. Hence for river depths greater than about 40 feet, the method loses in accuracy. The same objection then comes in that has been presented in connection with double floats, viz., that only a part of the vertical velocity section is measured.

III. Method by the current meter. There is a good deal of room for improvement in the current meter for effective work on the Lower Mississippi. Some improvement has no doubt been made recently in this direction. My experience is confined to the

Ellis meter. The chief objection to the method as used by me rests with the instrument itself. The objection presented to the rod-float and the double-float methods does not find a place in the method with the meter. It is possible to obtain results at all depths in a vertical plane within reasonable limits. The only question that remains is the accuracy with which a velocity can be measured at any particular depth. Under certain conditions great accuracy may be attained with the Ellis meter. In a clear stream, of not too great velocity or depth, the meter, having been carefully adjusted and rated, will do accurate work, and will continue to so long as the friction remains constant. It is easily handled, with suitable plant, and can be relied on. But in such a stream as the Mississippi, at high water, with its great depth and velocity, its silt and floating material, the instrument is entirely unsuited to the work. That a constant friction cannot be maintained under such conditions can hardly admit of a doubt to any one who has had an extended experience. There is nothing to prevent the journal-box from catching fine particles of sand, that not only increase the friction at the time, but produce a constant wearing effect that results in a permanent increase of friction. The mercury contact, as used at Columbus, is another source of variable friction, on account of certain parts of it that catch the sediment, a slight binding effect being the result. This change of friction can be detected by holding the instrument in the wind at frequent intervals during a set of observations. The velocity of wind required to turn the wheel will be found to vary materially. A thorough cleansing will often remove the difficulty temporarily. These differences of friction are not to be found in the equations, as the meter was always rated in clear water. The Ellis meter is very delicate, and is subject to be entirely destroyed by floating logs. From my experience I think it possible to construct a meter that will be free from most of the imperfections mentioned.

There is a considerable source of error in using any meter without anchoring. This is especially the case in windy weather, when it is impossible to avoid lateral movement. The rate of the meter is increased by a movement in either direction; hence there is no way of compensation. This error is likely to be considerable with a strong wind and slow current. For instance, a movement of a hundred feet would not be unreasonable, with a brisk wind, during a five-minute observation. That would correspond to about twenty-five revolutions of the meter-wheel, an average of five revolutions per minute. If the meter should make but thirty revolutions per minute, not an unreasonable supposition, the error would be 20 per cent. Such errors might be practically avoided by locating the position of the boat as frequently as possible, and correcting the velocities accordingly. The error from this source diminishes as the velocity increases.

Conclusions.—Of the three methods, the double float is considered the least accurate, but capable of producing fair results in a stream of even banks and bed. In a clear stream of limited depth, the methods by rod-floats and meter are, perhaps, equally accurate; when sediment is contained in any considerable quantity, the former of these is preferable. At high-water stages on the Lower Mississippi none of the methods can be relied on for perfect accuracy. In extreme high water rod-floats are considered preferable to the Ellis meter. I have no doubt but that a meter may be so constructed and manipulated as to do comparatively accurate work at all stages in the Lower Mississippi.

Reliability.—As to the reliability, the method by rod-floats seems to have the advantage, although that with the meter may be equally good within limits. From the facts already presented, the double-float method is considered very unreliable at high-water stages, and reliable only in a limited degree at all stages.

Economy.—When an anchorage, similar to that employed on the Upper Mississippi, can be used, the methods by rod-float and current-meter are equally expensive, either one being less so than that by double floats. Free rod-floats and double floats, located instrumentally, are equally expensive. In high water, when the use of a launch is necessary, the method by meter is the cheapest method of all.

No suggestions as to improvements will be offered.

Respectfully submitted.

J. H. DAVIS,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

3.—AT HELENA, ARK., F. A. YEAGER, ASSISTANT IN CHARGE.

HOTCHKISS, TENN., *June* 12, 1883.

SIR: In reply to your letter containing instructions from president of Commission concerning reports, &c., of different methods of gauging, I have to say that I did not work up my notes at Helena, so know nothing of the results. During the latter part of my stay there I ran rod-floats and the meter at the same time.

These observations show truly the comparative accuracy of the methods. In running rods I used the "plant" from stern of launch. This can be done, without loss of time, while the meter observations are being recorded. The plant is easily towed by placing the buoyed end in a skiff. The launch I had at Helena was admirably adapted to the use of gauging, and I found it perfectly safe at all times.

Very respectfully, your obedient servant,

F. A. YEAGER,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

Discharge observations, Helena, Ark.

The method of computing discharges at Helena, Ark., was as follows:

The cross-sections were plotted on cross-section paper, and their areas found by counting squares. Scale, 450 feet horizontal, 20 feet vertical, per square or inch.

The positions of floats or meter were plotted on the cross-sections, and the area divided into partial areas, the dividing lines being placed so as to give, as nearly as possible, a uniform depth to each partial area, or so that the depth at the velocity positions should be about the mean depth of the partial areas.

The maximum velocity was usually found at a depth considerably less than the maximum.

The velocities determined with rod-floats were corrected and reduced by Francis's formula—

$$v' = v\left[1 - .116\left(\sqrt{\frac{S-I}{S}} - 0.1\right)\right]$$

In which v' = reduced velocity, v = observed velocity, S = sounding, and I = immersion of rod.

The meter ratings were applied as directed in the field-notes.

The datum plane was taken at the highest gauge reading, 47.10 feet, on March 8.

The area of March 8 was taken as datum area, and all others obtained by successively adding and subtracting scours and fills.

Gauge-readings are means of readings taken at 6 a. m., 12 m., and 6 p. m.

Gauge same as used by Major Benyaurd.

Mean depth obtained by dividing water area by water width.

Mean datum depths obtained by dividing datum areas by datum width (= 49.10 feet).

Maximum depth copied from cross-section soundings in note-books.

The width, for dates on which no measurements were made, were derived from a curve obtained by plotting the measured widths to gauge.

Mean velocity obtained by dividing discharge by water area.

* * * * * * *

Discharges marked "Obs. incomplete" are nearly all computed on cross-sections of an earlier or later date, corrected for gauge.

In some cases velocities were also substituted from other dates; especially for partial areas at the ends of the sections or "end areas."

The failure to determine the width accurately, the lack of soundings near the river banks and on their slopes, and the lack of velocity observations near the banks, are sources, in some instances, of inaccuracy in the results.

* * * * * * *

MISSISSIPPI RIVER

Discharge observations at Helena, Ark.

Date.		Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Temperature, Fahr.		Method.	Remarks.
		Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.											
				Water.	Below datum.	Mean.	Mean datum.	Maximum.						Air.	Water.		
1882.		*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*		°	°		
Jan.	1	38.12											No observations taken.	No observations taken.			
	2	38.48	+0.36														
	3	38.80	+0.32														
	4	39.07	+0.27														
	5	39.27	+0.20														
	6	39.35	+0.08														
	7	39.43	+0.08														
	8	39.48	+0.05														
	9	39.48	0.00														
	10	39.40	−0.08														
	11	39.35	−0.05														
	12	39.33	−0.02														
	13	39.43	+0.10														
	14	39.53	+0.10														
	15	39.65	+0.12														
	16	39.92	+0.27														
	17	40.30	+0.38	209,777	242,834	43.5	49.5	74.5	4,828	(*)							*No discharge taken.
	18	40.70	+0.40														
	19	41.08	+0.38														
	20	41.38	+0.30														
	21	41.70	+0.32	214,497	240,787	44.3	49.0	72.0	4,839	−2,047	5.074	1.088,860				R. F.	
	22	41.95	+0.25														
	23	42.20	+0.25	217,725	241,591	44.8	49 2	73.0	4,856	+ 804	5.390	1,173,540				R. F.	
	24	42.45	+0.25	214.402	237,050	44.0	48.3	73.2	4,871	−4,541	5.367	1,150,695				R. F.	
	25	42.65	+0.20	219,282	240,956	45.0	49.1	68.5	4,871	+3,906	5.388	1,181,490				R. F.	
	26	42.85	+0.20														
	27	43.10	+0.25														
	28	43.33	+0.23	219,401	237,763	45.0	48.4	74.8	4,871	−3,193	(*)						*No discharge taken.
	29	43.45	+0.12														
	30	43.65	+0.20														
	31	43.81	+0.16	230,187	246,260	47.3	50.2	78.5	4,871	+8,497	5.593	1,287,435				R. F.	
Feb.	1	43.90	+0.09	232,474	248,060	47.7	50.5	77.8	4,871	+1,800	5.213	1,211,885				R. F.	
	2	43.99	+0.09	229,665	244,764	47.1	49.9	78.5	4,871	−3,296	4.971	1,141,665				M.	
	3	44.15	+0.16														

MISSISSIPPI RIVER—*Discharge observations at Helena, Ark.*—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.											
			Water.	Below datum.	Mean.	Mean datum.	Maximum.						Air.	Water.		
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*		°	°		
Feb. 4	44.35	+0.20	234, 138	247, 532	48.1	50.4	81.8	4, 871	+2, 768	4.982	1, 166, 475	No observations taken.	No observations taken.		M.	
5	44.47	+0.12														
6	44.65	+0.18	228, 528	240, 461	46.9	49.0	80.0	4, 871	−7, 071	4, 897	1, 119, 100				M.	
7	44.80	+0.15	233, 834	245, 037	48.0	49.9	81.5	4, 871	+4, 576	5.266	1, 231, 370				M.	
8	45.15	+0.35														
9	45.40	+0.25	241, 231	249, 511	49.5	50.8	77.5	4, 871	+4, 474	5.515	1, 330, 390				M.	
10	45.65	+0.25														
11	46.05	+0.40	237, 726	242, 840	48.8	49.5	84.0	4, 871	−6, 671	5.541	1, 317, 240				M.	
12	46.29	+0.24														
13	46.58	+0.29														
14	46.60	+0.02	240, 799	243, 234	49.4	49.5	81.0	4, 871	+ 394	5.897	1, 419, 990				M.	
15	46.60	0.00	233, 336(?)	235, 771	47.9	48.0	74.6	4, 871	−7, 463	5.778	1, 348, 215				M.	Observations imperfect.
16	46.57	−0.03														
17	46.28	−0.29	235, 563	239, 557	48.4	48.8	82.0	4, 671	+3, 786	5.703	1, 343, 415				M.	
18	46.08	−0.20	233, 463	238, 431	47.9	48.6	81.4	4, 871	−1, 126	5.996	1, 399, 845				M.	
19	46.05	−0.03														
20	46.00	−0.05														
21	45.85	−0.15					81.8									
22	45.72	−0.13														
23	45.66	−0.06														
24	45.54	−0.12	221, 379	228, 977	45.5	46.6	79.8	4, 871	+9, 454	5.812	1, 286, 655				M.	
25	45.48	−0.06	224, 921	232, 811	46.2	47.4	80.2	4, 871	−3, 834	5.504	1, 237, 965				M.	
26	45.42	−0.06														
27	45.41	−0.01														
28	45.52	+0.11	227, 977	235, 672	46.8	48.0	81.4	4, 871	+2, 861	5.470	1, 247, 035				M.	
Mar. 1	45.51	−0.01														
2	45.58	+0.07	228, 715	236, 118	47.0	48.1	83.8	4, 871	+ 446	5.427	1, 241, 235				M.	
3	45.74	+0.16	229, 338	235, 962	47.1	48.1	78.2	4, 871	− 156	5.603	1, 284, 980				M.	
4	46.06	+0.32														
5	46.57	+0.51														
6	47.00	+0.43	239, 616(?)	240, 103	49.2	48.9	83.5	4, 871	+4, 141	(*)						* No discharge taken.
7	47.02	+0.02	234, 199	234, 589	48.1	47.8	84.0	4, 871	−5, 514	6.432	1, 506, 375				M.	
8	47.10	+0.08	233, 411	233, 411	47.9	47.5	86.8	4, 671	−1, 178	6.677	1, 558, 485				M.	
9	47.09	−0.01														
10	46.92	−0.17														
11	46.81	−0.11														
12	46.69	−0.12														

13	46.54	−0.15	228,164	230,892	46.8	47.0	82.8	4,871	(−2,519)	6.247	1,562,240	No observations taken.			R. F.	Area interpolated.
14	46.40	−0.14	226,978	230,388	46.6	46.9	81.8	4,871	(− 504)	6.606	1,518,185				R. F.	Do.
15	46.20	−0.20	225,500	229,884	46.3	46.8	83.0	4,871	(− 504)	6.263	1,412,805				R. F.	Do.
16	46.15	−0.05	224,753	229,380	46.1	46.7	82.1	4,871	−4,031	(*)					R. F.	* No discharge taken.
17	46.02	−0.13	223,839.4	229,100	45.5	46.7	78.5	4,871	− 280	6,406	1,433,915.2				R. F.	Observations incomplete.
18	45.72	−0.30														
19	45.72	−0.00														
20	45.64	−0.08														
21	45.45	−0.19														
22	45.39	−0.06														
23	45.24	−0.15	220,338.0	229,398	44.9	46.7	81.5	4,871	+ 298							
24	45.12	−0.12														
25	45.07	−0.05														
26	44.98	−0.09														
27	44.90	−0.08	226,118.2	236,834	46.1	48.2	82.9	4,871	+7,486	6.092	1,377,516.6				M.	Observations incomplete.
28	44.78	−0.12														
29	44.66	−0.12	220,831.8	232,217	45.0	47.8	84.2	4,871	−4,617	5.710	1,259,224.8				M.	Do.
30	44.50	−0.16	220,346.0	233,011	45.0	47.5	84.1	4,871	+ 794	5.929	1,306,362.1				M.	Do.
31	44.35	−0.15	226,958.3	240,454	46.4	49.0	83.6	4,871	+7,443	5.808	1,317,186.5				M.	Do.
Apr. 1	44.15	−0.02												No observations taken.		
2	43.98	−0.17														
3	43.81	−0.17	223,242.5	239,373	45.8	48.8	81.6	4,870	−1,081	5.557	1,240,698.5				M.	
4	43.64	−0.17	221,586.7	236,736	45.5	48.2	81.4	4,870	−2,687	5.549	1,229,612.7				M.	Observation incomplete.
5	43.46	−0.18														
6	43.32	−0.14	218,121.3	234,829	44.8	47.8	81.6	4,870	−1,907	5.546	1,209,618.0				M.	
7	43.11	−0.21	222,284.6	240,015	45.6	48.9	82.0	4,870	+5,186	5.773	1,287,004.7				M.	
8	42.85	−0.26	221,047.1	239,986	45.4	48.9	81.7	4,870	− 29	5.488	1,281,986.6				M.	Do.
9	42.65	−0.20														
10	42.44	−0.21	217,746.2	238,678	44.9	48.6	82.5	4,854	−1,308	5.098	1,110,116.1				M.	Do.
11	42.14	−0.30	216,290.0	238,678	44.6	48.6	82.3	4,854	0	5.370	1,161,619.4	I	30		M.	XII=North or up-stream
12	41.70	−0.44	214,016.2	238,535	44.3	48.6	83.3	4,835	− 143	5.107	1,093,000.9	XII	8		M.	
13	41.36	−0.34	213,771.1	239,932	44.2	48.9	81.2	4,835	+1,397	5.021	1,073,852.8	XII	4		M.	
14	41.11	−0.25	212,570.5	239,938	44.0	48.9	80.9	4,835	+ 6	4.814	1,023,256.8				M.	Do.
15	40.85	−0.26	201,930.5	230,555	41.8	46.9	81.1	4,833	−9,383	4.777	964,668.6				M.	
16	40.55	−0.30														
17	40.31	−0.24	197,443.8	228,677	40.9	46.6	79.1	4,830	−1,878	4.845	956,535.0				M.	
18	40.12	−0.19														
19	40.02	−0.10	199,248.3	231,883	41.3	47.2	82.1	4,830	+3,206	4.815	959,477.0				M.	
20	39.86	−0.16	199,736.4	233,148	41.4	47.4	81.4	4,828	+1,260	4.750	948,710.8				M.	
21	39.66	−0.20	203,780.9	238,153	42.2	48.5	82.2	4,828	+5,010	4.615	940,351.8				M.	
22	39.30	−0.36														
23	38.85	−0.45														
24	38.10	−0.75	187,143.3	229,046	38.8	46.6	77.8	4,828	−9,107	4.449	832,542.7		0		M.	
25	37.30	−0.80	189,378.0	235,143	39.2	47.9	78.5	4,827	+6,097	4.238	802,550.0	VI	2		M.	
26	36.40	−0.90	185,263.2	235,372	38.4	47.9	77.1	4,826	+ 229	4.321	800,447.0				M.	
27	35.62	−0.78	178,217.5	232,090	36.9	47.3	77.1	4,826	−3,282	4.296	765,638.7	I	30–2		M.	
28	35.16	−0.46														
29	35.00	−0.16	181,349.1	238,214	37.6	48.5	75.2	4,825	+6,124	4.251	770,844	XII	6		M.	
30	35.07	+0.07														
May 1	35.05	−0.02	176,972.1	233,596	36.7	47.6	76.2	4,825	−4,618	4.331	766,545.2				M.	
2	35.02	−0.03	179,711.7	236,480	37.2	48.2	76.1	4,825	+2,884	4.385	788,073.8				M.	
3	35.08	+0.06	180,034.2	236,514	37.8	48.2	76.2	4,825	+ 34	4.220	759,723.8				M.	Observations incomplete.

MISSISSIPPI RIVER—*Discharge observations at Helena, Ark.*—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.								Air.	Water		
			Water.	Below datum.	Mean.	Mean datum.	Maximum.									
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*		°	°		
May 4	35.10	+0.02	181,064.7	237,448	37.5	48.4	75.9	4,825	+ 934	4.371	791,409.9	VI 4	No observations taken.		M.	
5	35.20	+0.10	183,561.2	239,463	38.1	48.8	76.8	4,825	+2,015	4.362	800,544.5	VI 5			M.	
6	35.23	+0.03														
7	35.30	+0.07														
8	35.43	+0.13	183,420.0	238,213	38.0	48.5	76.2	4,825	−1,250	4.321	792,485.2	VI 4			M.	
9	35.55	+0.12	181,847.0	236,061	37.7	48.1	78.5	4,826	−2,152	4.705	855,516.8	III 5			M.	Do.
10	36.35	+0.80	184,566.4	234,920	38.2	47.8	77.9	4,826	−1,141	4.324	798,030.0	1			M.	
11	37.02	+0.67	186,262.5	233,382	38.6	47.5	78.5	4,828	−1,538	4.620	860,605.6				M.	
12	38.10	+1.08	191,952.0	233,858	39.8	47.6	78.9	4,828	+ 476	4.495	862,978.6	X 30–5			M.	
13	39.05	+0.95	195,793.2	233,112	40.5	47.5	80.2	4,829	− 746	4.628	906,085.2	X 30–3			M.	
14	39.70	+0.65														
15	40.20	+0.50														
16	40.64	+0.44	201,803.0	231,443	41.8	47.1	81.7	4,831	−1,669	5.034	1,015,888.1	X 30–1			M.	
17	40.98	+0.34	211,638.6	239,636	43.8	48.8	80.9	4,833	+8,193	5.098	1,077,877.1				M.	
18	41.25	+0.27	210,231.1	236,924	43.5	48.3	80.5	4,833	−2,712	5.125	1,077,486.6				M.	
19	41.43	+0.18														
20	41.55	+0.12	210,918.0	236,161	43.6	48.1	81.8	4,835	− 763	5.271	1,111,696.1				M.	
21	41.67	+0.12														
22	41.77	+0.10	214,515.7	238,694	44.3	48.6	83.1	4,837	+2,538	5.145	1,103,861.1	XII 4			M.	
23	41.82	+0.05	210,677.7	234,614	43.6	47.8	83.2	4,837	−4,080	5.318	1,126,697.1				M.	
24	41.86	+0.04	212,997.5	236,741	44.0	48.2	83.1	4,837	+2,127	5.070	1,080,093.8	0			M.	
25	41.88	+0.02	210,570.7	234,217	43.5	47.7	81.2	4,837	−2,524	5.230	1,101,009.2	0			M.	
26	41.85	−0.03	215,319.0	239,110	44.5	48.7	82.5	4,837	+4,893	5.040	1,086,229.2	0			M.	
27	41.80	−0.05	213,592.5	237,625	44.2	48.4	82.8	4,837	−1,485	5.310	1,145,002.1					
28	41.81	+0.01														
29	41.78	−0.03	215,899.4	240,029	44.6	48.9	83.1	4,837	+2,404	5.048	1,089,962.3	XII 1			M.	
30	41.65	−0.13	210,585.5	235,343	43.6	47.9	82.5	4,835	−4,686	5.300	1,116,826.2					
31	41.49	−0.16														
June 1	41.32	−0.17	215,515.4	241,095	44.6	49.1	83.1	4,834	+5,752	5.082	1,095,271.7	0			M.	
2	41.18	−0.14	212,431.2	238,688	44.0	48.6	83.1	4,833	−2,407	5.010	1,065,217.1				M.	
3	41.10	−0.08	211,389.1	238,033	43.7	48.4	82.0	4,838	− 655	4.930	1,044,232.0	XII 2			M.	
4	41.10	−0.00														
5	41.12	+0.02	210,262.5	236,809	43.5	48.2	82.7	4,833	−1,224	5.035	1,058,616.5				M.	
6	41.19	+0.07														
7	41.27	+0.08														
8	41.32	+0.05	210,000.5	235,580	43.4	47.9	83.8	4,834	−1,229	4.938	1,037,031.8	0			M.	
9	41.32	0.00														

	10	41.30	−0.02	209,873.5	235,550	43.4	47.9	82.5	4,834	− 80	5.130	1,076,720.1			No observations taken.	M.	
	11	41.32	+0.02														
	12	41.35	+0.03	211,075.8	236,510	43.7	48.1	81.1	4,834	+ 960	5.090	1,074,572.7				M.	
	13	41.37	+0.02														
	14	41.29	−0.08														
	15	41.20	−0.09														
	16	41.00	−0.20	212,483.0	239,600	43.9	48.8	78.0	4,833	+3,090	4.843	1,029,055.7				R. F.	
	17	40.65	−0.35														
	18	40.20	−0.45														
	19	39.75	−0.45														
	20	39.20	−0.55	202,858.0	238,669	41.9	48.5	78.1	4,828	−1,431	4.520	958,257.3	VI	1		M.	
	21	38.85	−0.35	194,781.2	232,282	40.3	45.2	78.5	4,828	−5,887	4.845	943,799.4				M.	
	22	38.77	−0.08	197,982.5	235,869	41.0	48.0	78.5	4,827	+3,587	4.717	933,893.0				M.	
	23	38.85	+0.08	194,610.0	232,120	40.3	45.2	78.6	4,828	−3,749	4.727	920,000.4		0		M.	
	24	39.15	+0.30														
	25	39.28	+0.13														
	26	39.45	+0.17														
	27	39.59	+0.14	199,201.0	233,129	41.8	47.4	76.1	4,828	+1,009	4.909	977,859.0				M.	
	28	39.70	+0.11	196,868.0	230,265	40.8	46.8	77.1	4,828	−2,864	4.908	972,318.6				M.	
	29	39.72	+0.02	202,367.0	235,668	41.9	48.0	75.5	4,828	+5,403	4.657	942,482.4	VI	1		M.	
	30	39.66	−0.06	204,015.0	237,600	43.2	48.4	74.7	4,828	+1,932	5.102	1,040,905.0				M.	
July	1	39.52	−0.14	197,936.5	232,556	41.0	47.4	77.2	4,828	−5,044	4.809	951,873.6				M.	
	2	39.45	−0.07														
	3	39.25	−0.20	197,391.0	233,314	40.9	47.5	77.7	4,828	+ 758	4.957	978,522.2				M.	
	4	39.05	−0.20														
	5	38.82	−0.23	193,848.0	231,847	40.2	47.2	76.5	4,828	−1,467	4.993	967,966.7	XII	4		M.	
	6	38.75	−0.07														
	7	38.77	+0.02	196,272.0	234,512	40.7	47.8	76.3	4,828	+2,665	4.836	949,349.6	IV	30–4		M.	
	8	38.87	+0.10														
	9	39.15	+0.28														
	10	39.35	+0.20					78.5									
	11	39.55	+0.20					78.7									
	12	39.70	+0.15	201,314.5	235,064	41.7	47.9	78.9	4,828	+ 552	5.060	1,018,668.3	IX	3		M.	
	13	39.77	+0.07	202,123.0	235,535	41.9	48.0	76.5	4,828	+ 471	4.901	990,596.6				M.	
	14	39.77	0.00	198,284.4	231,696	41.1	47.2	78.7	4,828	−3,839	5.083	1,007,821.2	X	30–2		M.	
	15	39.65	−0.12	199,182.0	233,178	41.2	47.8	77.3	4,828	+1,477	5.164	1,028,504.0				M.	
	16	39.44	−0.21														
	17	39.10	−0.34	196,062.9	232,709	40.6	47.2	78.0	4,828	− 464	4.645	910,792.6				M.	Observation incomplete.
	18	38.63	−0.47	193,743.9	232,658	40.4	47.2	78.5	4,827	− 51	4.681	906,905.5	VI	3		M.	
	19	38.02	−0.61	193,015.8	234,874	40.0	47.7	77.5	4,827	+2,216	4.650	897,617.9				M.	
	20	37.28	−0.74	188,892.9	234,823	39.1	47.5	76.4	4,827	− 551	4.551	859,615.6	XII	2		M.	
	21	36.40	−0.88														
	22	35.35	−1.05	182,628.0	232,547	37.8	47.2	72.5	4,827	−1,776	4.379	799,762.0				M.	
	23	34.43	−0.92														
	24	33.63	−0.80	170,750.2	228,971	35.4	46.4	69.9	4,825	−3,576	4.254	728,155.8				M.	
	25	32.80	−0.83	168,338.9	230,555	35.0	46.8	70.8	4,805	+1,584	4.301	724,029.7				M.	
	26	31.96	−0.84	162,940.9	229,183	34.1	46.5	69.6	4,782	−1,372	4.218	687,350.5				M.	
	27	31.00	−0.96	160,341.8	231,162	33.7	46.9	68.8	4,756	+1,979	4.115	659,771.7	VI			M.	
	28	29.95	−1.05														
	29	28.72	−1.23	146,562.8	228,213	30.9	46.3	67.2	4,745	−2,949	4.069	595,494.3				M.	
	30	27.35	−1.37														
	31	26.25	−1.10	135,537.3	228,866	28.8	46.4	64.5	4,710	+ 658	3.987	540,376.3				M.	

MISSISSIPPI RIVER.—*Discharge observations at Helena, Ark.*—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.								Air.	Water.		
			Water.	Below datum.	Mean.	Mean datum.	Maximum.									
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*		°	°		
Aug. 1	25.15	—1.10	130,097.7	228,596	27.7	46.4	62.3	4,689	— 270	3.862	502,379.6		No observations taken.		M.	Observation incomplete.
2	24.25	—0.90	121,583.7	224,292	26.1	45.5	63.7	4,667	—4,304	3.809	463,157.5				M.	
3	23.52	—0.73	116,071.2	222,182	24.9	45.0	62.5	4,654	—2,110	3.782	438,952.2				M.	
4	23.06	—0.46														
5	22.58	—0.48	111,135.6	221,614	24.0	44.9	62.1	4,639	— 568	3.796	421.839.2	VI 4			M.	
6	22.15	—0.43														
7	21.85	—0 30	112,047.3	225,910	24.2	45.8	65.3	4,632	+4,296	3.758	421,077.4	VI 5			M.	
8	22.00	+0.15	111,532.5	224,700	24.1	45.6	61.8	4,634	—1,210	3.741	417,265.9	VII 30–2			M.	
9	22.70	+0.70	116,791.2	226,714	25.2	46.0	62.1	4,637	+2,014	4.014	468,749.6	XII 3			M.	
10	23.55	+0.85	121,168.8	227,143	26.0	46.1	62.8	4,655	+ 429	3.968	480,803.5	XII 2			M.	
11	24.17	+0.62	126,414.7	229,499	27.1	46.5	63.4	4,666	+2,356	3.858	487,766.5	0			M.	
12	24.47	+0.30	127,815.8	229,499	27.4	46.5	61.1	4,670	0	3.909	499,670.9	VI 1			M.	
13	24.35	—0.12														
14	24.05	—0.30	132,040.8	235,684	28.3	47.8	64.0	4,663	+6,185	3.955	522,196.8	VII 30–2			M.	
15	23.77	—0.28														
16	23.45	—0.32	119,566.0	226,007	25.6	45.8	62.5	4,662	—9,677	3.816	456,204.4				M.	
17	23.06	—0.39	128,820.0	232,079	26.6	47.1	61.5	4,659	+6,072	3.879	480,410.0				M.	
										3.664	453,787.0				R. F.	
18	22.58	—0.48	121,876.0	232,371	26.2	47.1	61.9	4,656	+ 292	3.833	467,209.0	XII 3			M.	
19	22.10	—0.48	119,921.0	232,650	25.8	47.2	60.2	4,653	+ 279	3.646	437,258.0				R. F.	
20	21.65	—0.45														
21	21.35	—0.30	111,757.0	227,974	24.0	46.2	61.8	4,648	—4,676	3.725	416,336.0	VI 1			M.	
22	21.12	—0.23	111,955.0	229,241	24.1	46.5	62 8	4,648	+1,267	3.768	421,872.0				M.	
			111,955.0		24.1		62.8	4,643								
23	20.75	—0.37								3.661	409,919.0				R. F.	
24	20.32	—0.43	111,760.0	232,778	24.2	47.2	62.5	4,626	+3,537	3.654	408,505.0				M.	
25	19.85	—0.47	103,987.0	227,177	22.5	46.1	62.5	4,616	—5,661	3.552	369,463.0	IV 30–1			M.	
26	19.25	—0.60	97,887.0	223,843	21.2	45.3	60.6	4,603	—3,884	3.638	354,295.0	XII 1			M.	
27	18.62	—0.63														
28	17.92	—0.70	89,487.0	221,546	19.6	44.9	54.8	4,574	—1,797	3.508	310,446.0	XII 4			M.	
29	17.33	—0.59	92,090.0	226,844	20.2	46.0	58.2	4,562	+5,298	3.528	324,900.0				M.	
30	16.80	—0.53	89,671.0	226,840	19.7	46.0	57.5	4,550	— 4	3.607	323,510.0				R. F.	
31	16.40	—0.40	82,281.0	221,268	18.1	44.5	56.0	4,540	—5,572	3.383	278,376.0	XII 2			M.	
Sept. 1	16.10	—0.30														
2	15.85	—0.25	82,985	222,962	20.7	45.2	57.7	4,000	+1,694	3.347	277,062	XII 1			R. F.	
3	15.74	—0.11														
4	15.68	—0.06														

	5	15.60	−0.08	83,908	228,868	22.1	45.4	56.4	3,750	+ 006	3.221	267,896	XII	3	No observations taken.	R. F.	
	6	15.60	0.00	78,311	219,181	20.9	44.4	57.2	3,750	−4,687	3.170	248,287	XII	3		R. F.	
	7	15.65	+0.05														
	8	15.75	+0.10	83,565	223,673	22.2	45.4	55.1	3,770	+4,602	3.618	302,813				M.	
	9	15.82	+0.07	87,848	227,884	22.0	46.2	54.2	4,000	+4,011	3.381	207,095	XII	2		R. F.	
	10	16.02	+0.20														
	11	16.25	+0.23	84,122	222,435	21.0	45.1	54.8	4,015	−5,449	3.481	292,887				M.	
	12	16.41	+0.16														
	13	16.34	−0.07	91,616	229,567	22.8	46.6	55.8	4,020	+7,132	3.466	317,541				M.	
	14	10.23	−0.09														
	15	15.98	−0.25	89,422	228,818	22.3	46.4	55.4	4,010	− 749	3.699	330,844				M.	Do.
	16	15.67	−0.31	85,445	226,045	22.7	45.8	55.1	3,760	−2,778	3.511	300,043				M.	Do.
	17	15.36	−0.31														
	18	15.05	−0.31	84,250	237,175	22.5	46.1	54.9	3,740	+1,130	3.219	271,255	IV	4		R. F.	
	19	14.90	−0.15	79,443	222,928	21.3	45.2	55.8	3,730	−4,247	3.389	268,883	VI	4		R. F.	
	20	15.25	+0.35	80,379	222,559	21.4	45.1	54.6	3,750	− 369	3.409	274,055	VI	4		R. F.	
	21	16.08	+0.83														
	22	17.10	+1.02	89,381.9	224,006	20.2	45.4	56.2	4,419	+1,447	3.670	328,063.7	XII	4		R. F.	
	23	17.90	+0.80	89,781.3	220,785	19.4	44.8	53.9	4,033	−3,221	3.427	307,639.9	XII	4		M.	
	24	18.20	+0.30														
	25	17.90	−0.30	94,681.8	225,685	20.4	45.8	58.3	4,633	+4,000	3.785	353,595.5	XII			R. F.	
	26	17.30	−0.60	91,098.9	224,879	19.7	45.7	56.7	4,625	− 806	3.630	330,728.8	XII			R. F.	
	27	16.52	−0.78	85,573.8	222,950	18.6	45.2	56.0	4,595	−1,929	3.457	295,803.8	III	2		R. F.	Do.
	28	15.70	−0.82	81,230.4	222,052	21.3	45.0	54.9	3,809	− 898	3.292	267,383.7				R. F.	
	29	14.95	−0.75	79,324.2 79,324.2	222,973 222,973	21.3	43.2	53.9	3,730	+ 921	2.941 3.158	233,281.7 250,517.1				M. R. F.	
	30	14.25	−0.70	76,752.2	222,947	21.6	45.2	53.6	3,546	− 26	3.284	252,034.5				R. F.	
Oct.	1	13.60	−0.65														
	2	12.00	−0.60	75,278.7	220,065	22.0	44.6	54.0	3,420	−2,882	3.212	241,793.8				R. F.	Do.
	3	12.58	−0.42	72,456.3	218,666	21.5	44.3	53.6	3,857	−1,899	2.793	202,391.8				M.	
	3	12.58	−0.42	72,456.3	218,666	21.5	44.3	53.6	3,857	−1,899	3.097	221,382.2				R. F.	
	4	12.20	−0.38	70,857.9	218,324	21.7	44.3	53.2	3,262	− 842	3.106	220,116.6				R. F.	
	5	11.65	−0.55	70,213.4	219,140	21.7	44.4	52.7	3,226	+ 816	2.959	207,780.2				R. F.	
	5	11.65	−0.55	70,213.4	219,140	21.7	44.4	52.7	3,226	+ 816	2.806	197,052.7				M.	
	6	11.50	−0.15	68,134.5	217,532	22.2	44.1	52.4	3,060	−1,608	2.833	198,010.0				M.	
	6	11.50	−0.15	68,134.5	217,532	22.2	44.1	52.4	3,060	−1,608	2.980	203,015.1				R. F.	
	7	11.50	0	67,359.0	216,757	22.0	43.9	52.0	3,060	− 775	2.759	185,865.7				M.	
	7	11.50	0	67,359.0	216,757	22.0	43.9	52.0	3,060	− 775	2.920	196,700.9				R. F.	
	8	11.50	0														
	9	11.48	−0.02	67,638.6	217,097	22.1	44.0	52.0	3,060	+ 340	2.963	200,420.8				M.	
	9	11.48	−0.02	67,638.6	217,097	22.1	44.0	52.0	3,000	+ 340	2.976	201,260.8				R. F.	
	10	11.37	−0.11	65,014.2	214,809	21.2	43.5	52.5	3,053	−2,288	2.980	198,715.9				M.	
	10	11.37	−0.11	65,014.2	214,809	21.2	43.5	52.5	3,053	−2,288	3.035	197,822.5				R. F.	
	11	11.28	−0.09	65,203.2	215,272	21.4	43.6	52.8	3,037	+ 463	2.926	190,805.7				R. F.	
	12	11.18	−0.10														
	13	11.19	+0.01														
	14	11.12	−0.07	63,660.3	214,215	20.9	43.4	52.4	3,037	−1,057	2.954	188,054.5				R. F.	Do.
	15	11.02	−0.10														
	16	10.90	−0.12														
	17	10.72	−0.18	64,320.3	216,085	21.3	43.8	52.2	3,014	+1,870	2.804	180,361.1				R. F.	
	18	10.60	−0.12														
	19	10.40	−0.20	63,964.9	215,684	21.5	43.7	52.5	2,970	− 401	2.723	174,198.7	XII	5		R. F.	

MISSISSIPPI RIVER.—*Discharge observations at Helena, Ark.*—Continued.

Date.	Gauge.		mensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.								Air.	Water.		
			Water.	Below datum.	Mean.	Mean datum.	Maximum.									
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*		°	°		
Oct. 20	10.08	−0.32	60,733.8	213,403	20.4	43.3	51.3	2,970	−2,281	2.790	169,449.8	XII 4	No observation.		M.	
20	10.08	−0.32	60,733.8	213,403	20.4	43.3	51.3	2,970	−2,281	2.770	168,228.0	...			R. F.	
21	9.85	−0.23	59,538.0	212,891	20.0	43.2	49.5	2,970	− 512	2.887	171,863.4	...			M.	
21	9.85	−0.23	59,538.0	212,891	20.0	43.2	49.5	2,970	− 512	2.760	164,344.4	...			R. F.	
22	9.90	+0.05	...	...	...	...	...	...	...	...	...	...			...	* Gauge record for week ending October 28 missing. Taken from Benyaurd report.
23	9.85	−0.05	59,075.0	212,428	19.9	43.1	49.5	2,970	− 463	2.790	164,846.4	...			M.	Observation incomplete.
23	9.85	−0.05	59,075.0	212,428	19.9	43.1	49.5	2,970	− 463	2.789	164,737.9	...			R. F.	Do.
24	9.80	−0.05	59,139.5	212,640	19.9	43.1	49.5	2,970	+ 212	2.910	172,086.2	...			M.	
24	9.80	−0.05	59,139.5	212,640	19.9	43.1	49.5	2,970	+ 212	2.734	161,694.4	...			R. F.	
25	9.85	+0.05	59,280.9	212,633	19.9	43.1	49.5	2,970	− 7	2.908	172,396.8	...			M.	Do.
25	9.85	+0.05	59,280.9	212,633	19.9	43.1	49.5	2,970	− 7	2.761	163,651.5	...			R. F.	Do.
26	10.05	+0.20	...	...	...	...	...	...	...	...	...	...			...	
27	10.20	+0.15	60,302.8	212,615	20.3	43.1	50.0	2,970	− 18	2.947	177,734.4	...			M.	Do.
28	10.22	+0.02	60,360.7	212,615	20.3	43.1	50.0	2,970	0	3.084	186,138.8	...			M.	
28	10.22	+0.02	60,360.7	212,615	20.3	43.1	50.0	2,970	0	2.828	170,642.9	...			R. F.	Do.
29	10.40	+0.18	...	...	...	...	...	...	...	...	...	...			...	
30	10.35	−0.05	...	...	...	...	...	...	...	...	...	...			...	
31	10.30	−0.05	60,593.0	212,610	20.4	43.1	50.1	2,970	− 5	3.055	185,092.0	...			R. F.	Do.
Nov. 1	10.37	+0.07	...	...	...	...	...	...	...	...	...	...			...	
2	10.48	+0.11	...	...	...	...	...	...	...	...	...	...			...	
3	10.55	+0.07	...	...	...	...	...	...	...	...	...	...			...	
4	10.58	+0.03	...	...	...	...	...	...	...	...	...	...			...	
5	10.67	+0.09	...	...	...	...	...	...	...	...	...	...			...	
6	10.78	+0.11	...	...	...	...	...	...	...	...	...	...			...	
7	10.88	+0.10	...	...	...	...	...	...	...	...	...	...			...	
8	10.90	+0.02	61,920.9	212,155	22.4	43.0	51.9	2,761	− 455	3.328	206,065.5	...			M.	The small area east of sand-bar not included in the November observation.
9	10.92	+0.02	...	...	...	...	...	...	...	...	...	...			...	
10	11.03	+0.11	62,803.8	212,652	22.7	43.1	52.0	2,761	+ 497	3.316	208,329.8	VI			M.	Observat'n incomplete.
11	11.12	+0.09	62,748.9	212,330	22.7	43.0	52.1	2,765	− 322	3.305	211,179.4	VI 4			M.	Do.
12	11.25	+0.13	...	...	...	...	...	...	...	...	...	...			...	
13	11.55	+0.30	...	...	...	...	...	...	...	...	...	...			...	
14	11.75	+0.20	...	...	...	...	...	...	...	...	...	...			...	
15	11.98	+0.23	...	...	...	...	...	...	...	...	...	...			...	

4.—AT HAYS' LANDING, MISS., HOMER P. RITTER, ASSISTANT IN CHARGE.

NOTE.—Assistant Ritter has a report in course of preparation, but the necessity for his services in other branches of work has delayed its completion.—S. S. L.

Discharge observations Hays' Landing, Miss.

In filling out the accompanying blanks for this station, the mean gauge, water area, scour and fill, mean velocity, discharge, direction of wind and method were copied from MS. $\frac{792}{c.f.}$, Assistant H. P. Ritter.

Temperature of the air is the mean of three readings taken each day at 6 a. m., 12 m., and 6 p. m. Copied from note-book 890.

Datum was taken at a gauge reading of 38 feet and a surface width of 2,770 feet.

Datum area for this gauge and width was obtained from the water area of March 15 by applying the increase of area due to the difference in gauge readings. This gives for datum area 169,015 square feet.

Datum area for January 2 was next obtained by adding to the water area of this date the area obtained by multiplying the mean of datum surface width and surface width of January 2, by the difference between the gauge reading on January 2 and elevation of datum plane, *i. e.*, 38 feet.

Datum area, as thus obtained, for January 2=158781.

Subsequent datum areas were obtained by the successive addition or subtraction of the scours and fills.

Mean depth was obtained by dividing the water area by the water width.

Mean datum depth was obtained by dividing the datum area by datum width.

Maximum depth was copied from field notes No. 888, and is the deepest actual sounding taken.

Rise for January 2 was obtained by taking the difference between the gauge reading on January 1 at 12 m. and the mean gauge for January 2.

Rise or fall between any other two consecutive days is obtained by taking the difference of the mean guage readings for those days.

In column headed "method"........ {
M=Meter.
R=Rod floats.
D. F=Double floats.

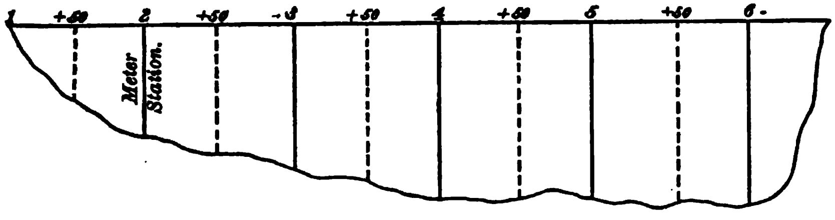
The manner of computing partial areas, the manner of dividing the section into partial areas, and of distributing velocities, is as follows:

Commencing at the shore line, the notes read thus—

Station............ {
1
+50
2
+50
3
&c.

The stations marked 1, 2, 3, &c., are meter stations, while at the other stations soundings only were taken. The first partial area is from 1 to 2+50, the velocity for this partial area being observed at 2.

The second partial area is from 2+50 to 3+50, the velocity for this partial area being observed at 3; and so on.



The partial areas were computed from the recorded soundings.

Sum of partial area = total area. Partial area multiplied by its velocity = partial discharge.

Sum of partial discharges = total discharge.

Total discharge divided by total area = mean velocity.

Scour or fill is the difference between the water area as observed, and that as computed from the change of gauge.

MISSISSIPPI RIVER.

Discharge observations at Hays' Landing, Miss.

Date.		Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Temperature, Fahr.		Method.	Remarks.
		Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.								Air.	Water.		
				Water.	Below datum.	Mean.	Mean datum.	Maximum.									
1882.		Feet.	Feet.	Sq. feet.	Sq. feet.	Feet.	Feet.	Feet.	Feet.	Sq. feet	Feet.	Cubic feet.		°	°		
Jan.	1	29.22															
	2	29.89	+0.67	186,742	158,781	51.3	49.4	91.8	2,665		5,866	733,794	0 0			R.	Checked twice.
	3	30.30	+0.41														
	4	30.70	+0.40														
	5	31.05	+0.35														
	6	31.39	+0.34														
	7	31.58	+0.19														
	8	31.78	+0.20														
	9	32.00	+0.22														
	10	32.14	+0.14														
	11	32.25	+0.11														
	12	32.40	+0.15														
	13	32.63	+0.23														
	14	32.70	+0.07														
	15	32.80	+0.10														
	16	33.08	+0.28														
	17	33.25	+0.17														
	18	33.48	+0.23														
	19	33.70	+0.22														
	20	33.99	+0.29														
	21	34.28	+0.29	161,534	171,788	59.6	62.0	99.0	2,710	+13,007	6,056	978,300	XII			R.	
	22	34.45	+0.17														
	23 24	34.60	+0.15	154,326	163,699	56.9	59.1	94.7	2,710	− 8,089	5,915	912,805	XII			R.	
	25 26	35.00	+0.40	155,641	163,944	57.4	59.2	96.7	2,710	+ 245	5,990	932,353	VI			R.	
	27	35.20	+0.20														
	28	35.40	+0.20														
	29	35.45	+0.05														
	30	35.60	+0.15														
	31	35.71	+0.11	158,460	164,823	57.5	59.5	97.5	2,756	+ 879	5,862	928,928	light			R.	
Feb.	1	35.78	+0.07	158,889	165,046	57.7	59.6	97.2	2,756	+ 228	5,850	929,425	VI light			R.	
	2	35.85	+0.07	160,809	166,773	58.3	62.1	95.8	2,756	+ 1,727	5,839	942,226	0			R.	
	3	35.99	+0.14														

	4	86. 14	+0. 15														
	5	86. 10	−0. 04														
	6	86. 13	+0. 03	159, 894	166, 101	58. 0	59. 6	99. 7	2, 756	− 1, 672	5, 968	954, 294	0				R.
	7	86. 20	+0. 07														
	8	86. 26	+0. 06														
	9	86. 32	+0. 06														
	10	86. 36	+0. 04	165, 262	169, 820	60. 0	61. 4	99. 0	2, 756	+ 4, 719	5, 882	972, 111	0				R.
	11	86. 41	+0. 05	165, 563	169, 997	60. 1	61. 4	99. 4	2, 756	+ 177	6, 124	1, 018, 855	0				R. & M.
	12	86. 49	+0. 08														
	13	86. 60	+0. 11														
	14	86. 69	+0. 09	163, 606	167, 255	59. 4	60. 4	98. 0	2, 756	− 2, 742							
	15	86. 75	+0. 06														
	16	86. 82	+0. 07														
	17	36. 89	+0. 07	165, 314	168, 412	60. 0	60. 8	101. 8	2, 756	+ 1, 157	5, 783	956, 066	0				R.
	18	36. 91	+0. 02														
	19	87. 01	+0. 10														
	20	37. 06	+0. 05	165, 715	168, 344	60. 1	60. 8	103. 0	2, 756	− 68				heavy			
	21	87. 15	+0. 09	168, 791	171, 172	61. 2	61. 8	101. 9	2, 756	+ 2, 828	6, 038	1, 019, 196	0				R.
	22	87. 17	+0. 02	163, 277	165, 608	59. 2	59. 8	100. 1	2, 756	− 5, 569	5, 829	951, 718	XII				R.
	23	87. 22	+0. 05	167, 126	169, 829	60. 6	61. 1	100. 2	2, 756	+ 3, 726	5, 842	976, 413	0				R.
	24	87. 27	+0. 05														
	25	87. 38	+0. 11														
	26	87. 42	+0. 04														
	27	87. 52	+0. 10	164, 729	166, 091	59. 8	60. 0	98. 0	2, 756	− 3, 238			VI				
	28	87. 64	+0. 12														
Mar.	1	87. 60	−0. 04														
	2	87. 46	−0. 14	169, 967	171, 478	61. 7	61. 9	100. 0	2, 756	+5, 387	5, 697	968, 081	0				R.
	3	87. 32	−0. 14	167, 852	169, 780	60. 9	61. 8	99. 0	2, 756	−1, 698	5, 684	954, 092	0				R.
	4	87. 18	−0. 14														
	5	87. 10	−0. 08														
	6	87. 07	−0. 03	169, 828	171, 981	61. 4	62. 1	99. 5	2, 756	+2, 151	5, 961	1, 009, 402	XII				R.
	7	87. 00	−0. 07														
	8	87. 12	+0. 12														
	9	87. 30	+0. 18	171, 636	173, 605	62. 8	62. 7	99. 0	2, 756	+1, 674	5, 734	984, 164		heavy			R.
	10	87. 30	+0. 00														
	11	87. 30	+0. 00														
	12	87. 48	+0. 18														
	13	87. 64	+0. 16	172, 024	173, 070	62. 4	62. 5	99. 2	2, 756	− 535	5, 707	981, 792	0				R.
	14	87. 77	+0. 13	170, 363	171, 050	61. 6	61. 8	100. 8	2, 765	−2, 020	5, 448	928, 093	VI				R.
	15	87. 96	+0. 19	168, 905	169, 052	61. 0	61. 0	102. 2	2, 770	−1, 998	5, 588	943, 824	0				M.
	16	88. 17	+0. 21	171, 870	171, 435	62. 0	61. 9	102. 4	2, 770	+2, 383	5, 781	984, 950	0				M.
	17	38. 28	+0. 11	172, 157	171, 417	62. 2	61. 9	102. 0	2, 770	− 18	5, 656	978, 671	VI	heavy			M.
	18	88. 41	+0. 13														
	19	88. 51	+0. 10														
	20	88. 59	+0. 08	172, 105	170, 513	61. 0	61. 6	103. 8	2, 820	− 904	5, 444	936, 954	VI	heavy			M.
	21	87. 66	−0. 93	170, 274	171, 260	61. 8	61. 8	103. 0	2, 756	+ 747			XII				
	22	87. 10	−0. 56	169, 262	171, 792	61. 4	62. 0	101. 0	2, 756	+ 532			XII				
	23	86. 78	−0. 32	169, 779	173, 205	61. 6	62. 5	101. 5	2, 756	+1, 413	5, 573	946, 110	0				M.
	24	86. 65	−0. 13	169, 763	173, 547	61. 6	62. 7	102. 5	2, 756	+ 342	5, 539	940, 345	0				M.
	25	36. 50	−0. 15														
	26	86. 40	−0. 10														
	27	86. 31	−0. 09														

MISSISSIPPI RIVER.—*Discharge observations at Hays' Landing, Miss.*—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.											
			Water.	Below datum.	Mean.	Mean datum.	Maximum.						Air.	Water.		
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*		°	°		
Mar. 28	36.17	−0.14	167,224	172,331	60.7	62.2	100.4	2,756	−1,216	......	......	0	......	......	......	
29	36.06	−0.11	164,614	170,010	59.7	61.4	101.7	2,756	−2,321	5,557	914,772	VI	......	......	R.	
30	35.95	−0.11	......	......	......	......	......	......	......	......	......	......	......	......	......	
31	35.84	−0.11	......	......	......	......	......	......	......	......	......	......	......	......	......	
Apr. 1	35.71	−0.13	......	......	......	......	......	......	......	......	......	......	......	......	......	
2	35.64	−0.07	......	......	......	......	......	......	......	......	......	......	......	......	......	
3	35.53	−0.11	......	......	......	......	......	......	......	......	......	......	......	......	......	
4	35.46	−0.07	164,760	171,815	60.4	62.0	98.5	2,730	+1,805	5,559	915,899	0	......	......	R.	
5	35.39	−0.07	164,067	171,299	60.1	61.8	99.5	2,730	− 516	5,565	913,084	VI light	......	......	M.	
6	35.30	−0.09	163,855	171,346	60.1	61.9	98.7	2,725	+ 47	5,662	927,724	0	......	......	M.	
7	35.24	−0.06	163,372	171,026	60.0	61.7	98.5	2,725	− 320	5,527	903,015	0	......	......	M.	
8	35.15	−0.09	......	......	......	......	......	......	......	......	......	......	......	......	......	
9	35.09	−0.06	......	......	......	......	......	......	......	......	......	......	......	......	......	
10	35.04	−0.05	161,192	169,390	59.5	61.2	99.5	2,707	−1,636	5,404	871,011	0	......	......	M.	
11	34.94	−0.10	......	......	......	......	......	......	......	......	......	......	......	......	......	
12	34.90	−0.04	161,763	170,326	59.7	61.5	99.0	2,708	+ 936	......	......	XII heavy	......	......	......	
13	34.88	−0.02	165,540	174,158	61.1	62.9	101.0	2,708	+3,832	5,566	921,430	XII heavy	......	......	R.	
14	34.83	−0.05	160,424	169,177	59.2	61.1	98.9	2,708	−4,981	5,430	871,112	XII heavy	......	......	R.	
15	34.77	−0.06	......	......	......	......	......	......	......	......	......	......	......	......	......	
16	34.69	−0.08	......	......	......	......	......	......	......	......	......	......	......	......	......	
17	34.62	−0.07	......	......	......	......	......	......	......	......	......	......	......	......	......	
18	34.60	−0.02	164,385	173,773	60.8	62.7	99.2	2,704	+4,596	5,338	877,457	0	......	......	R.	
19	34.59	−0.01	160,656	170,072	59.4	61.4	99.0	2,704	−3,701	6,037	969,866	VI	......	......	M.	
20	34.47	−0.12	166,432	176,159	61.5	63.5	99.5	2,704	+6,087	5,561	925,584	0	......	......	M.	
21	34.44	−0.03	163,664	173,733	60.5	62.6	98.5	2,704	−2,426	5,490	900,034	......	......	......	M.	
22	34.49	+0.05	......	......	......	......	......	......	......	......	......	......	......	......	......	
23	34.46	−0.03	......	......	......	......	......	......	......	......	......	......	......	......	......	
24	34.33	−0.13	......	......	......	......	......	......	......	......	......	......	......	......	......	
25	34.25	−0.08	......	......	......	......	......	......	......	......	......	......	......	......	......	
26	34.15	−0.10	159,935	170,788	59.8	61.6	98.5	2,699	−2,945	5,358	856,940	VI heavy	......	......	M. & R.	
27	34.04	−0.11	161,463	172,613	59.8	62.2	98.0	2,700	+1,825	5,137	829,491	XII heavy	......	......	M. & R.	
28	33.89	−0.15	159,893	171,434	59.2	61.8	99.1	2,700	−1,179	5,181	828,337	0	......	......	M. & R.	
29	33.77	−0.12	......	......	......	......	......	......	......	......	......	......	......	......	......	
30	33.55	−0.22	......	......	......	......	......	......	......	......	......	......	......	......	......	
May 1	33.37	−0.18	160,499	173,455	59.7	62.5	98.0	2,688	+ 2,021	5,290	848,970	0	......	......	M. & R.	
2	33.21	−0.16	162,009	175,881	60.3	63.2	97.1	2,688	+ 1,926	5,150	834,375	0	......	......	R.	
3	33.06	−0.15	158,883	172,658	59.2	62.3	95.3	2,686	− 2,723	5,014	796,675	VI light	......	......	R.	

	4	32.93	−0.13	154,934	169,092	57.7	61.0	94.0	2,684	− 3,566	4,938	764,459	VI	heavy	......	......	R.
	5	32.83	−0.10	157,268	171,674	58.6	61.9	95.8	2,682	+ 2,582	5,023	790,081	VI	heavy	......	......	R.
	6	32.74	−0.09	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	7	32.69	−0.05	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	8	32.69	−0.00	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	9	32.68	−0.01	156,353	171,162	58.3	61.7	95.0	2,682	− 512	4,888	764,272	VI	very h'vy	......	......	R.
	10	32.84	+0.16	159,071	173,438	59.3	62.5	97.5	2,683	+ 2,276	5,037	801,217	......	......	......	......	R.
	11	32.95	+0.11	159,041	173,112	59.2	62.4	95.8	2,686	− 326	5,207	828,058	IX	light	......	......	M.
	12	33.08	+0.13	158,884	172,636	59.1	62.2	96.5	2,687	− 506	5,300	841,851	IX	heavy	......	......	M.
	13	33.32	+0.24	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	14	33.55	+0.23	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	15	33.71	+0.16	162,824	174,848	60.3	63.0	99.0	2,701	+ 2,242	5,609	918,342	0		......	......	M.
	16	33.85	+0.14	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	17	33.93	+0.08	162,684	174,113	60.2	62.8	97.0	2,703	− 735	5,825	866,310	IX	heavy	......	......	R.
	18	33.99	+0.06	161,054	172,322	59.6	62.1	92.9	2,703	− 1,791	......	......	0		......	......	......
	19	34.05	+0.06	162,982	174,101	60.3	62.8	96.7	2,704	+ 1,779	5,671	924,337	0		......	......	R.
	20	34.09	+0.04	162,672	173,669	60.1	62.6	99.0	2,705	− 432	5,553	903,247	VI	heavy	......	......	R.
	21	34.17	+0.08	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	22	34.16	−0.01	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	23	34.17	+0.01	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	24	34.20	+0.03	164,777	175,489	60.9	63.3	98.5	2,707	+ 1,820	5,555	915,381	XII	light	......	......	R.
	25	34.21	+0.01	160,880	171,552	59.4	61.8	98.0	2,707	− 3,937	5,630	905,820	0		......	......	R.
	26	34.22	+0.01	164,159	174,804	60.6	63.0	99.8	2,707	+ 3,252	5,574	914,942	VI	light	......	......	R.
	27	34.18	−0.04	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	28	34.19	+0.01	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	29	34.17	−0.02	165,931	176,725	61.3	63.7	99.2	2,707	+ 1,921	5,869	973,885	XII	light	......	......	M.
	30	34.14	−0.03	166,106	176,981	61.4	63.8	98.8	2,707	+ 256	5,989	994,879	VI	light	......	......	M.
	31	34.18	+0.04	......	......	......	......	......	......	......	......	......	......	......	......	......	......
June	1	34.15	−0.03	167,397	178,244	61.8	64.3	98.8	2,707	+ 1,263	6,265	1,048,750	XII	light	......	......	M.
	2	34.09	−0.06	166,800	177,796	61.6	64.1	99.9	2,707	− 448	6,062	1,011,169	VI	heavy	......	......	M.
	3	34.11	+0.02	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	4	34.12	+0.01	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	5	34.12	0.00	167,449	178,363	61.9	64.3	99.2	2,707	+ 567	6,169	1,033,014	XII		......	......	M.
	6	34.12	0.00	168,147	179,062	62.1	64.6	99.8	2,707	+ 699	6,292	1,057,990	XII		......	......	M.
	7	34.11	−0.01	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	8	34.13	+0.02	166,965	177,843	61.7	64.1	100.0	2,707	− 1,219	6,133	1,023,999	VI	light	......	......	M.
	9	34.14	+0.01	165,809	176,670	61.3	63.7	98.0	2,707	− 1,173	6,249	1,036,221	XII		......	......	M.
	10	34.12	−0.02	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	11	34.13	+0.01	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	12	34.12	−0.01	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	13	34.10	−0.02	159,857	170,840	59.1	61.6	97.1	2,707	− 5,830	6,134	980,576	VI	light	85	......	M.
	14	34.07	−0.03	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	15	34.05	−0.02	161,481	172,599	59.7	62.2	95.2	2,707	+ 1,759	5,976	964,962	VI		83	......	M.
	16	34.06	+0.01	161,732	172,810	59.7	62.3	96.9	2,707	+ 211	6,188	1,000,769	VI		80	......	M.
	17	34.03	−0.03	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	18	34.00	−0.03	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	19	33.96	−0.04	161,334	172,682	59.6	62.3	97.8	2,706	− 128	6,222	1,003,772	VI		81	......	M.
	20	33.94	−0.02	......	......	......	......	......	......	......	......	......	......	......	......	......	......
	21	33.91	−0.03	160,960	172,457	59.5	62.2	95.8	2,705	− 225	6,187	987,833	VI		84	......	M.
	22	33.89	−0.02	160,111	171,662	59.2	61.9	95.3	2,705	− 795	6,130	981,418	VI	light	85	......	M.
	23	33.85	−0.04	160,306	171,952	59.2	62.0	96.7	2,706	+ 290	6,159	987,351	0		85	......	M.
	24	33.81	−0.04	......	......	......	......	......	......	......	......	......	......	......	......	......	......

MISSISSIPPI RIVER.—*Discharge observations at Hays' Landing, Miss.*—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.								Air.	Water.		
			Water.	Below datum.	Mean.	Mean datum.	Maximum.									
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*		°	°		
June 25	83.78	−0.03														
26	83.76	−0.02	162,060	173,950	59.9	62.7	95.1	2,704	+ 1,998			VI light	84			
27	83.75	−0.01	160,546	172,464	59.4	62.2	98.0	2,704	− 1,486			VI light	85			
28	83.73	−0.02														
29	83.72	−0.01	160,598	172,618	59.4	62.2	97.5	2,703	+ 154	5,908	948,773	VI light	85		M.	
30	83.68	−0.04	160,618	172,738	59.4	62.3	97.0	2,702	+ 120	5,728	919,967	VI heavy	84		R.	
July 1	83.67	−0.01	161,183	173,830	59.7	62.5	96.8	2,702	+ 592	5.364	864,596	VI heavy.	85		R.	
2	83.63	−0.04														
3	83.57	−0.06	159,416	171,833	59.0	61.9	95.5	2,701	−1,497	5.566	887,361	VI	78		R.	
4	83.50	−0.07														
5	83.45	−0.05														
6	83.38	−0.07	158,069	170,985	58.6	61.6	95.5	2,696	− 848	5.491	868,002	XII	78		R.	
7	83.34	−0.04	159,912	172,950	59.4	62.8	95.8	2,693	+1,965	5.604	896,143	XII	74		R.	
8	83.83	−0.01														
9	83.81	−0.02														
10	83.27	−0.04	157,108	170,321	58.4	61.4	94.5	2,690	−2,629			VI light.	84			
11	83.23	−0.04														
12	83.27	+0.04	158,952	172,151	50.1	62.1	94.0	2,690	+1,880	5.443	865,184	VI heavy.	70		R.	
13	83.23	−0.04	158,177	171,498	58.8	61.8	94.5	2,690	− 653	5.645	892,911	VI heavy.			M.	
14	83.18	−0.05	157,111	170,566	58.4	61.5	93.8	2,689	− 932	5.599	879,704	0			R.	
15	83.16	−0.02	158,171	171,694	58.8	61.9	92.0	2,690	+1,128	6.035	954,633	VI light.			M.	
16	83.14	−0.02														
17	83.13	−0.01	159,837	172,926	59.8	62.8	91.5	2,689	+1,232			VI				
18	83.14	+0.01	160,832	174,395	59.8	62.9	96.0	2,690	+1,469	5.732	921,865	VI			M. & R.	
19	83.08	−0.06	160,683	174,421	59.8	62.9	97.0	2,689	+ 26	5.749	923,814		83		M.	
20	83.02	−0.06	161,236	175,135	60.1	63.1	95.0	2,685	+ 714	5.744	926,115	0	85		M.	
21	82.92	−0.10	160,958	175,125	59.9	63.1	94.1	2,685	− 10			0	82			
22	82.82	−0.10														
23	82.64	−0.18														
24	82.29	−0.35	158,672	174,514	59.8	62.9	93.5	2,675	− 611			XII	83			
25	82.00	−0.29	156,293	172,924	58.2	62.3	93.9	2,674	−1,590	6.024	941,545	XII heavy.	82		M.	
26	81.55	−0.45	155,126	172,947	58.1	62.3	92.9	2,671	+ 23	5.880	904,891	XII heavy.	80		M.	
27	81.13	−0.42	154,475	173,430	57.9	62.5	92.9	2,667	+ 483	5.570	860,474	VI heavy.	79		M.	
28	80.65	−0.48	153,228	173,444	57.5	62.5	92.0	2,664	+ 14	5.404	828,028	VI heavy.	78		M.	
29	80.09	−0.56														
30	29.32	−0.77														
31	28.48	−0.89	147,462	173,509	55.6	62.6	87.5	2,651	+ 155			VI heavy.	83			

Aug.	1	27.30	−1.13	145,833	174,952	55.1	63.1	88.5	2,646	+1,858	4.809	701,448		81		M.
	2	26.13	−1.17	140,791	173,017	53.3	62.4	86.2	2,643	−1,935	4.749	668,597	VI light.	85		M.
	3	25.00	−1.13	137,508	172,698	52.2	62.3	85.3	2,634	− 319	4.573	628,814	VI light.	81		M.
	4	23.75	−1.25	135,745	174,229	51.7	62.8	85.0	2,628	+1,531	4.274	580,151	VI	81		M.
	5	22.48	−1.27													
	6	21.61	−0.87													
	7	20.52	−1.09													
	8	19.76	−0.76	123,318	172,234	47.4	62.1	78.5	2,601	−1,995	3.846	474,344	VI heavy.	81		M.
	9	19.10	−0.66	121,595	172,240	46.8	62.1	79.0	2,599	+ 6			VI light.	81		
	10	18.83	−0.27	119,539	170,873	46.0	61.6	78.5	2,599	−1,367	4.116	492,048	XII heavy.	77		M.
	11	18.81	−0.02	119,596	170,995	46.0	61.6	77.7	2,599	+ 122	4.267	510,337	XII light.	78		M.
	12	19.10	+0.29													
	13	19.46	+0.36													
	14	19.66	+0.20													
	15	19.70	+0.04	124,152	173,224	47.7	62.4	80.0	2,601	+2,229	3.995	496,043	VI	85		R.
	16	19.63	−0.07	124,049	173,303	47.7	62.5	83.5	2,601	+ 79	3.916	485,826	VI heavy.	84		R.
	17	19.47	−0.16	123,542	173,225	47.5	62.4	80.0	2,599	− 78	4.015	495,977	VI light.	84		R.
	18	19.45	−0.02	122,903	172,638	47.3	62.2	78.9	2,599	− 587	3.860	474,445	XII heavy.	81		R.
	19	18.86	−0.59													
	20	18.40	−0.46													
	21	18.03	−0.37	119,083	172,502	46.0	62.2	78.9	2,589	− 136			XII light.	78		
	22	17.60	−0.43	117,282	171,800	45.4	61.9	77.7	2,586	− 702	4.181	490,380	XII light.	84		M.
	23	17.18	−0.42													
	24	16.91	−0.27	113,680	169,982	44.0	61.3	76.9	2,582	−1,818			VI light.	79		
	25	16.46	−0.45													
	26	16.06	−0.40	113,603	172,111	44.0	62.0	75.4	2,579	+2,129	3.677	417,741	VI light.	80		R.
	27	15.77	−0.29													
	28	15.27	−0.50													
	29	14.60	−0.67	109,434	171,672	42.9	61.9	74.0	2,548	− 439	3.472	379,981		81		R.
	30	13.90	−0.70	106,725	170,745	42.0	61.6	73.9	2,541	− 927	3.336	356,006	VI light.	79		R.
	31	13.33	−0.57	105,497	170,961	41.7	61.6	72.4	2,529	+ 216	3.283	346,335	0	85		R.
Sept.	1	12.57	−0.76	103,149	170,533	40.9	61.5	71.0	2,522	− 428	3.172	327,229	VI heavy.	82		R.
	2	12.20	−0.37													
	3	11.75	−0.45													
	4	11.41	−0.34													
	5	11.11	−0.30													
	6	10.93	−0.18	97,374	168,872	39.0	60.9	69.2	2,495	−1,661	3.188	310,410	XII light.	82		R.
	7	10.79	−0.14	97,104	169,001	39.0	60.9	68.5	2,493	+ 129	3.104	301,411	XII light.	83		R.
	8	10.69	−0.10	96,896	169,042	38.9	60.9	69.2	2,490	+ 41	3.171	307,288	XII heavy.	79		R.
	9	10.63	−0.06	97,459	169,767	39.2	61.2	68.2	2,489	+ 725	3.202	312,069	XII heavy.	76		R.
	10	10.67	+0.04													
	11	10.73	+0.06	98,277	170,324	39.5	61.4	71.0	2,489	+ 557			0	74		
	12	10.85	+0.12	97,364	169,125	39.1	61.0	69.5	2,490	−1,199	3.317	322,985	0	79		M.
	13	11.00	+0.15	98,772	170,147	39.6	61.3	69.0	2,496	+1,022	3.564	352,016	VI light.	78		M.
	14	11.13	+0.13	98,965	170,015	39.6	61.3	70.9	2,497	− 132	3.403	336,748	0	82		M.
	15	11.19	+0.06	101,374	172,273	40.6	62.1	71.2	2,497	+2,258	3.602	365,182	0	78		M.
	16	11.12	−0.07	100,458	171,545	40.2	61.8	70.0	2,497	− 728	3.590	360,643	0	80		M.
	17	10.95	−0.17													
	18	10.74	−0.21	97,954	169,989	39.3	61.3	69.5	2,491	−1,556	3.540	346,726	VI	81		M.
	19	10.41	−0.33	97,609	170,452	39.3	61.4	69.0	2,483	+ 463	3.496	341,255	VI light.	83		M.
	20	10.12	−0.29	96,881	170,456	39.1	61.4	68.9	2,477	+ 4	3.446	333,835	VI light.	82		M.
	21	9.91	−0.21	94,829	168,912	38.3	60.9	68.4	2,476	−1,544	3.280	311,026	XII light.	77		M.

MISSISSIPPI RIVER.—*Discharge observations at Hays' Landing, Miss.*—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.								Air.	Water.		
			Water.	Below datum.	Mean.	Mean datum.	Maximum.									
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*		°	°		
Sept. 22	9.94	+0.03														
23	10.36	+0.42	96,077	169,044	38.7	60.9	69.5	2,482	+ 132	3.193	306,767	XII heavy.	69		R.	
24	11.06	+0.70														
25	11.70	+0.64	100,640	170,264	40.1	61.4	71.0	2,508	+1,220	3.451	347,330	VI light.	72		R.	
26	12.23	+0.53														
27	12.34	+0.11	103,007	171,085	40.9	61.7	73.0	2,520	+ 771	3.270	336,835	0	73		R.	
28	12.14	−0.20	102,019	170,538	40.6	61.5	71.3	2,513	− 497	3.182	324,584	VI light.	76		M.	
29	11.65	−0.49	101,975	171,723	40.7	61.9	71.0	2,507	+1,185	3.015	307,426	VI light.	80		M.	
30	11.00	−0.65	97,857	169,231	39.2	61.0	69.9	2,498	−2,492	3.008	294,313	VI light.	75		M.	
Oct. 1	10.32	−0.68														
2	9.70	−0.62	96,277	170,880	39.0	61.6	69.0	2,469	+1,649	3.055	294,127	XII light.	76		M.	
3	9.05	−0.65	95,010	171,210	38.9	61.7	70.1	2,445	+ 330	2.913	276,771	0	76		M.	
4	8.33	−0.72														
5	7.88	−0.45	93,388	172,445	38.6	62.2	68.5	2,419	+1,235				77			
6	7.35	−0.53	90,891	171,217	37.7	61.7	67.4	2,414	−1,228	2.692	244,683	III heavy.	74		M.	
7	6.92	−0.43	88,874	170,234	37.0	61.4	66.8	2,399	− 983	2.701	240,075	XII	75		M.	
8	6.59	−0.33														
9	6.47	−0.12														
10	6.41	−0.06	89,082	171,614	37.2	61.9	66.9	2,392	+1,380	2.605	231,909	XII light.	81		M.	
11	6.49	+0.08														
12	6.56	+0.07	87,980	170,203	36.8	61.4	65.8	2,394	−1,411			0 clear.	79			
13	6.60	+0.04	89,035	171,174	37.1	61.7	65.9	2,394	+ 971	2.623	233,574	XII heavy.	75		M.	
14	6.38	−0.22	88,834	171,488	37.1	61.8	65.9	2,394	+ 314	2.627	233,358	XII light.	76		M.	
15	6.27	−0.11														
16	6.22	−0.05														
17	6.22	0.00	88,070	171,106	36.8	61.7	65.9	2,390	− 382	2.284	201,115	0	72		M.	
18	6.29	+0.07														
19	6.25	−0.04														
20	6.18	−0.07														
21	6.20	+0.02														
22	6.25	+0.05														
23	6.55	+0.30	90,480	172,688	37.8	62.3	66.1	2,394	+1,582	2.841	256,908	XII heavy.	57		M.	
24	6.74	+0.19	90,365	172,168	37.7	62.1	63.1	2,394	− 520	2.653	239,698	VI light.	63		M.	
25	6.98	+0.24	90,963	172,192	37.9	62.1	66.9	2,399	+ 24	2.684	244,102	VI light.	67		M.	
26	6.96	−0.02	90,945	172,222	37.9	62.1	67.5	2,401	+ 30	2.636	239,718	VI light.	69		M.	
27	6.77	−0.19	89,554	171,275	37.3	61.7	66.0	2,399	− 947	2.680	240,003	VI	71		M.	
28	6.61	−0.16	89,114	171,231	37.1	61.7	65.9	2,399	− 44	2.616	233,144	VI	71		M.	

	29	6.51	−0.10													
	30	6.50	−0.01	89,128	171,508	37.2	61.8	65.9	2,397	+ 272	2.555	227,784	VI heavy.	67	......	M.
	31	6.42	−0.08	89,267	171,827	37.3	61.9	66.0	2,396	+ 324	2.561	228,572	VI light.	77	......	M.
Nov.	1	6.30	−0.12	88,907	171,767	37.1	61.9	66.1	2,394	− 60	2.500	222,260	VI light.	69	......	M.
	2	6.18	−0.12	87,996	171,148	36.8	61.7	66.8	2,389	− 624	2.520	221,786	0	79	......	M.
	3	6.05	−0.13	86,801	170,259	36.4	61.4	65.2	2,387	− 384	2.511	217,940	XII heavy.	64	......	M.
	4	6.00	+0.04	86,411	169,773	36.2	61.2	65.2	2,388	− 486	2.652	220,542	XII light.	61	......	M.
	5	6.11	+0.02													
	6	6.19	+0.08	86,365	169,488	36.2	61.1	65.8	2,389	− 285	2.609	225,358	0	60	......	M.
	7	6.22	+0.03	86,625	169,676	36.3	61.2	65.4	2,389	+ 188	2.636	228,312	0	71	......	M.
	8	6.24	+0.02	86,970	169,973	36.4	61.3	65.0	2,389	+ 297	2.566	223,148	VI light.	71	......	M.
	9	6.31	+0.07	88,590	171,402	37.1	61.8	65.2	2,391	+1,429	2.608	231,001	VI heavy,	71	......	M.
	10	6.36	+0.05	86,211	168,915	36.0	60.9	66.1	2,392	−2,487	2.606	224,700	VI very h'vy.	73	......	M.
	11	6.40	+0.04	87,270	169,890	36.5	61.2	66.1	2,392	+ 975	2.632	229,735	VI very h'vy.	69	......	M.
	12	6.45	+0.05													
	13	6.68	+0.23	86,911	168,866	36.8	61.0	66.1	2,395	−1,024	2.750	239,025	XII very h'vy.	47	......	M.
	14	6.78	+0.10	89,076	170,780	37.2	61.6	66.2	2,396	+1,914	2.735	248,652	VI light.	46	......	M.
	15	7.04	+0.26	89,635	170,715	37.3	61.6	67.1	2,402	− 65	2.803	251,272	0	55	......	M.
	16	7.32	+0.28	87,857	168,276	36.5	60.7	66.9	2,407	−2,489	2.861	251,379	0	55	......	M.
	17	7.65	+0.33	89,358	168,964	37.0	61.0	67.0	2,416	+ 688	2.918	260,730	XII	55	......	M.
	18	8.01	+0.36	90,191	168,931	37.2	61.0	67.5	2,425	− 33	......	......	XII heavy.	46	......	......
	19	8.43	+0.42													
	20	8.66	+0.23	91,219	168,387	37.3	60.8	68.1	2,448	− 544	3.014	274,945	XII heavy.	41	......	M.
	21	8.95	+0.29	92,904	169,362	37.9	61.1	68.5	2,450	+ 974	3.067	284,909	XII light.	44	......	M.
	22	9.11	+0.16	93,556	169,623	38.1	61.2	68.8	2,458	+ 261	3.091	289,149	VI heavy.	47	......	M.
	23	9.34	+0.23	94,808	169,797	38.3	61.3	69.3	2,462	+ 174	3.103	292,665	XII light.	50	......	M.
	24	9.46	+0.12	93,746	168,952	38.0	61.0	69.5	2,465	− 845	......	......	XII light.	49	......	......
	25	9.54	+0.08													

5.—AT RED RIVER LANDING AND HEAD OF THE ATCHAFALAYA, JOHN EWENS, ASSISTANT IN CHARGE.

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., June 16, 1883.

SIR: I have the honor to inform you that, in accordance with your instruction, I left Saint Louis with my party for Red River Landing, Louisiana, on November 26, 1881. I arrived at my destination with party on the morning of December 3, 1881. Preparations were immediately made for beginning the discharge work. Everything else was sacrificed to meet this end, as I desired to obtain as large a range of discharge measurements at the different stages of the river as possible. In view of this objective, the elaboration of details of the other work was left until the discharge work was fully inaugurated. On day of arrival, an exhaustive reconnaissance was made for the purpose of selecting suitable discharge sections. After sounding a number of sections, a section located about 200 feet below the warehouse at Red River Landing was selected for gauging the Mississippi. The section for gauging the Atchafalaya is located at Merrick, about 3,000 feet from head of the river. The section in Old River is situated about one mile from its juncture with the Mississippi. The section on Red River is situated about 1¼ miles from its passage into Old River. All of these sections presented the usual and requisite qualifications of a good discharge section, the foremost among which were high banks, and freedom from eddies and other disturbing elements. The section in a bend for transverse velocity curve work was located in "Brunette Bend," 21 miles below Red River Landing and 3 miles above New Texas. The regular serial work covered by my instructions necessitated the gauging of the Mississippi daily with but one exception, the exception being the day allotted each month for work in the bend. The Atchafalaya was to be gauged not less than once a week, and daily with the Mississippi, if possible. The party succeeded in gauging both rivers daily during the entire flood. When the rivers reached the ordinary stage, the Atchafalaya was gauged weekly, which was thought to be sufficient. In connection with the work mentioned above, the party gauged Red and Old Rivers, also Bayou des Glaises. During the flood, the Grand cut-off and Bayou des Glaises were examined. The bend section was worked monthly. Instructions to perform bend work were not given the party until some months after entering the field. Observations were taken in Old River as often as necessary to determine the direction of flow with reference to the Mississippi. The party carried out completely and successfully not only the detail work given above, but did a vast amount of additional work, such as rating meters, making experiments to compare the meter with other plans, &c. The amount of field-work done may be briefly summarized as follows: A total of 310 discharges were measured, 227 of which were measured on the Mississippi, 78 on the Atchafalaya, 3 on Old River, 1 on Red River, and 1 on Bayou des Glaises; the bend section was worked 6 times; a large number of vertical curves of velocity were also taken. The work of establishment having been completed, the regular discharge work was begun on December 13th, 1881, and continued without interruption from this date until the close of the work in November, 1882. The work during the great flood was carried on under the most adverse circumstances imaginable. The observing stations had to be built above the water; the transit station was built in water over ten feet deep. The platforms for the observers at the lining-in stations were built in trees. By working in this manner, the party continued the work without interruption during the entire flood, thus securing a complete and reliable set of discharge observations which will be of inestimable value, as they cover the greatest flood discharge ever measured on the Mississippi River. It was the intention originally to do all the velocity work with the meter, but the late arrival of the steam launch, and some unavoidable delays, caused by losing some of the connecting parts of the meter, made it necessary to resort to float methods until the meter could be employed permanently. The regular plan of conducting the discharge work was as follows: The cross-section was first sounded. Every sounding was located by an angle deflected from a 1,000-foot base-line situated at right angles to the cross-section line. Between 90 and 100 soundings were taken daily. The soundings were taken from the launch, the launch running up above the section line, then drifting back to take the sounding. When above the line, the recorder on board held a signal flag above his head until on exact line, when it was dropped quickly, this being the signal for the transit-man on shore to take the angle locating the sounding. On every tenth sounding a red flag was raised, as a check on the work of shore and launch party. The tangent of each angle was worked out as it was taken, thus giving the distance apart of the soundings, and showing at once any gaps that might exist. By this means, errors were eliminated at once in the field. This system of sounding should be regarded as conventional. I can conceive of no other plan equal to it, as you locate each sounding just where the leadsman happens to cast his lead. And where such a large number of soundings are taken as at the Red River Landing station, you will during a series of days' work touch nearly all points of the section. If the fixed signal system were employed, you touch simply the same stations and you know nothing of the changes that are taking place between them. For sounding at this station, light leads and lines were used in preference to the usually heavy ones employed.

The velocity work with floats was performed in the following manner: The floats were timed over a 100-foot path; the transit of float over the ranges inclosing this path was located with transit, the bases of location being 1,000 and 1,100 feet for upper and lower ranges respectively. At the section lines a very satisfactory substitute for transits to line the floats was used. It consisted of fine silk threads, weighted with lead plumb bobs and suspended from the apex of tripods erected over the lining hubs on the sections. These threads gave a line I consider practically as good as that given by the cross hairs of a transit. These stations were established on both banks, half of the river being observed from each bank; there were days, however, when the atmosphere was clear enough to take all the observations from one bank. At each of the lining-in stations, a rude stand was erected for holding the electric key and recording. The floats were all started from points located on a section 500 feet above the upper extremity of the float path. This section was divided into a sufficient number of stations to cover all the velocities between the banks; the angles corresponding to these stations were calculated, so that to start the float, it was necessary simply to run out this section line until the line indicated by signal from the transit-man was reached. At this point the float starter would launch the float; the depth or immersion of float was always determined from soundings taken previously. Double floats were always run at mid depth. Rods were run as close to the bottom as possible. After the float was launched, the boat party followed the float over the path and noted very closely its action; if anything unnatural was visible, the float was always repeated until a visibly satisfactory observation was obtained. To avoid confusion, a system of signals for repeating floats was adopted. When a float was to be repeated for reasons discovered by the boat party, the float starter indicated the fact by waving a flag. When a float was to be repeated for reasons discovered by the shore party, the transit-man waved a flag. The transit of the float over the sections at extremity of path was signaled to the transit-man by telegraph, by the observer at the lining stations, the observer also acting as time-keeper. For a brief time when the flood was at its height, the locations at path extremities were omitted, and a float path of 100 feet was assumed. The washing away of the telegraph supports necessitated this change.

When rods were used, a special form of rod had to be devised, as at the deeper portions of the sections, the weight attached to rod has to be so great that it is necessary to arrange the attachments in such manner that the weight may be detached before withdrawing the rod. If such an arrangement is not made, you will, in a majority of cases, break your rod. If you attempt to make your rod heavy enough to prevent breaking, you will find it will be too cumbersome to handle in a boat. The form of rod devised for this work was the same as that shown in sketch "A." The lower extremity of this rod is made T-shaped, as at "R." To the weight "*w*" two pan-shaped metallic wrists are attached at *vv*. These strips fit closely to the T portion of the rod, as shown in the figure. The terminal ends spring outward at *cc'* for reasons that will presently be given. A string passes from the weight at "*h*" to the top of the rod. This string is the one used in raising the weight. The small ring at *zz'* is held by two ring strings that pass from this ring to the top of the rod. The method of launching and withdrawing the rod is as follows: The rod is taken in tow by the skiff. The launching station having been reached, the weight is attached by simply fitting the weight into the groove at "*u*" and turning the wrists down on the T portion of the rod, making them fast by springing the ring over the spring ends as at *gg'*. This being done, the rod is lowered gradually into the water until the desired immersion is reached. After the observation is complete, to withdraw the rod, it will be simply necessary to give a brisk jerk on the ring strings, which will set the rod free. As the rod is held by party in the boat the weight pressing downward will throw back the wrists which are hinged at *bb'*. The weight having been detached, you will find that the rod will shoot rapidly upward and lie flat on the water surface, before the lead weight can be drawn to the surface. While one of the boat crew is raising this weight, the other members of the crew will have taken the float in tow and reached the next station, without loss of time, breakage, or any inconvenience whatever. So it is seen the launching of this type of float is reduced simply to a minimum as to time.

The work with the meter was all conducted from the catamaran. The location was done by intersecting signals established on the bank. This system of location was necessitated by reason of the entire force having duties on the river. The plan of working was as follows: The catamaran was lashed to the launch in such a manner that, the suspending wire holding the meter, the throttle valve of engine and the engineer would all be in plane of the section when on line; the pilot taking such a position with reference to the intersecting signals as to bring the meter exactly on the station. This plan enabled the pilot and engineer to keep the plant in perfect position without any appreciable variation. The greater number of the discharge velocity observations were taken by holding the plant up against the current. It was found by making a large number of experiments with plant anchored, that the results taken with the plant free or anchored did not differ. Experiments were made frequently at the various stations in order to fully satisfy myself that the plans did not differ appreciably. In doing the work by holding up, care was always taken to commence and end the observations on exact line. The vast amount of time it would take to withdraw and cast large anchors, the continued presence of passing boats, and the vast fields of drift that are present in the river continually at flood stages, necessitated the adoption of this plan.

In taking vertical velocity-curve observations, the plant was always anchored. The meter was worked from the stern of the catamaran. The connection and general arrangement of the apparatus was as follows: The suspending and guy-wires were attached to two model cog-reels which were attached to the platform, in the bow and stern respectively. The suspending wire passed from the stern-reel over to an iron sheave held by a pulley stanchion that projected about 4 feet upwards from end of the stern; this stanchion leaned outward far enough to let the meter weight clear the platform. The wire passed from this sheave to the loop-clasp of the meter-weight pipe. The guy-wire passed from the stern-reel to a wooden sheave held by a pulley-block in the long beam that projected from the center of the platform outward between the bows of the catamaran. This beam was about 20 feet long, and was made adjustable, as its length depends on depth of immersion of the meter. Its length with reference to the hypotenuse and altitude of the triangle, of which it forms the base, must be such as will keep the suspending wire vertical. The guy-wire passes from this sheave to a small clamp that is attached to a cylinder of brass 1 inch long, which works up and down on the pipe of meter weight. This little cylinder has a clamp-screw for adjusting it to the pipe at any desired height. The arrangements described above will without doubt keep apparatus perpendicular to the section. In this connection I would say that were it possible to use a rigidly fixed pipe for holding the meter it would, I think, be preferable. But we know on the Lower Mississippi at certain stages this would be impossible, on account of immense quantities of submerged drift that will be met with continually.

In *Annales des Ponts et Chaussées*, by M. De La Greve, a very good form of pipe attachment is described. I give a sketch of this in figure "B." It consists of a piece of gas-pipe of desired length with a small longitudinal section removed, as shown in the horizontal section, figure "*a*." The meter slides down this pipe and is kept from turning by the projection at *c*. Though the device is a good one, yet the guy plan, when worked carefully, is the more satisfactory and is always practicable. The battery connections were first made through the reels direct; but it was found advisable afterwards to use two small insulated wires for conducting the electric currents. These wires served also as safety wires, as the suspending wire often broke. In such cases the conducting wires would hold the meter. The guy would prevent loss were these wires missing, but it would not prevent the injury that would be done by withdrawing it with the guy-wire. The battery connections were centralized in such manner that but two simple connections on the meter completed the circuit. The battery and register-cases were combined and attached by angle-wires to the catamaran in such manner as to prevent loss. The stern reel was graduated and connected with an index pointer in such manner that depths of less than one-tenth of a foot could be read off.

The meter weight consisted of a lead cylinder weighing about 60 pounds. This cylinder was about 10 inches long and about 4¼ inches in diameter. A piece of ¾-inch gas-pipe passed through the cylinder. This pipe was about 16 inches long. The meter was attached to this pipe. The top of the pipe terminated in a screw-tap containing the suspending wire clamp. A small brass cylinder containing the guy-wire clamp was attached to this pipe also.

The furniture of the catamaran consisted of a small skiff, a large sweep oar, a long pike pole, an ax, and set of signal flags. Life preservers for the party were also on board. This outfit, and careful training of the party, prevented losses or accidents of any kind during the year, which was one of the most trying ones that in all probability will ever be encountered by parties on work of this character.

The velocity work done with double floats, rod-floats, and the meter was refined in every detail possible, as the necessity of employing three methods made it absolutely necessary to secure as nearly perfect results as possible, in order to make a comparison of the methods, and to make the discharge work in general satisfactory. The final reductions and the curves of velocity, area, and discharge deduced attest fully the accuracy of the work in detail.

The cause of not using the meter exclusively was due to the non-arrival of the launch and the loss of one of the connecting parts of the meter. Work with the meter was a perfect success from the start. After the equipment for making repairs was received from Saint Louis, not a single observation was taken by any other plan. Aside from this, I think the partial use of floats fortunate, as it will admit of a comparison of the methods and under favorable circumstances.

Besides the regular serial work done by the party, an exhaustive examination of the grand cut-off near Black Hawk was made during the flood. No flow through the cut-off was manifest. In Red River, from the mouth of the bayou cut-off down to Spanish Fort, the current was very feeble during the flood. An examination was also made of the Bayou des Glaises from the mouth to Hamburg, La. A discharge was also taken through a section about ¼ mile above the mouth of this bayou.

The notes were kept written up daily. The calculations were kept up daily, and a discharge sheet transmitted weekly up to August 17, 1882. After that date no computation could be made, as my assistant, Mr. John C. Cammack, left the party, he having received official orders to report in Saint Louis.

A daily log was kept, also a daily summary. The latter book contained the gauge readings, temperatures of the air and water, direction and force of the wind, dates of rain, frosts, fogs, and other marked features of the weather; also a complete record of the kind and amount of work done daily, the condition of the data, &c.

When work on the river was impossible, the boat party were engaged in the shop, fabricating such articles as were required on the work, making repairs on the apparatus, &c.

The launch was kept in complete repair and improved considerably by the party. The stability of the launch and its excellent running power were fully established by the excellent condition it was in at the close of the work, after having been used severely for over a year. For work of this character launches of this type have no equal.

The results of the daily discharge observations are given so fully in the tables of calculations and curve charts appended to this report, that a discussion of them here is unnecessary.

The work was inspected by you in person on January 25 and 26, 1882, and again on November 23, 1882. The meter work in actual operation on the river, the plant, and all the auxiliary apparatus were inspected on November 23, 1882, by General H. G. Wright, Chief of Engineers, United States Army, General C. B. Comstock, president Mississippi River Commission, Maj. Amos Stickney, Maj. Chas. R. Suter, United States Army, Maj. B. M. Harrod, Prof. Henry Mitchell, and Judge R. C. Taylor.

The work of the party at Red River Landing closed on November 26, 1882, orders having been received on that date to close the work and proceed with party to the Bonnet Carré crevasse. The note-books and field supplies no longer required were transferred to the steamer Mississippi on November 26, 1882. All the calculations of discharge work for both the Mississippi and Atchafalaya; charts showing deduced curves of velocity, discharge, and area; a map showing relative position of cross-sections; a map of transverse velocity curves taken in bend; a map showing contour of river bed at all of the sections, are all appended to this report.

Before closing this part of my report I desire to acknowledge the valuable assistance rendered by my assistant, Mr. John C. Cammack; the cheerful, prompt, and accurate manner in which he performed his arduous duties during the most trying times of the great flood, and at all times while with my party, is worthy of praise which words are but meager to express.

The changes and action of the river in the vicinity of Red River Landing, and some facts regarding the flood height of 1882 and previous years, and other personal observations made during the year, will doubtless be of interest in connection with the above report.

The weather during the year was variable. It rained on 143 days; fogs prevailed periodically from January 5 to June 13. The minimum temperature of the air for the year was 38° (on January 30). The maximum temperature of the air was 98° (on August 17). The minimum temperature of the water was 44° (on January 30); the maximum temperature of the water was 84° (on June 30, July 1 to 6, August 17 to 31).

The temperatures of the water were taken at points of the section from bank to bank, and as near mid-depth as possible. These temperatures were valuable during the flood. The arrival of flood water from the Tensas region was shown by the temperature of the Atchafalaya during the flood. On the day preceding the arrival on the Atchafalaya of the flood water referred to, the temperatures of the Mississippi and Atchafalaya were the same, which might be expected, as the Mississippi was discharging a portion of its waters into the Atchafalaya via Old River. On the day of the arrival of additional flood water on the Atchafalaya the temperature of the Atchafalaya rose several degrees, thus indicating the source of the additional volume of water present in the river.

The river was rising on December 3, 1881, the day of the arrival of party at Red River Landing, and continued rising until December 6, when it began falling. It fell until December 27, on which date it began rising, and continued until March 27, 1882, on which date it reached its maximum stage not only for the year, but the highest ever known. The gauge at 12.30 o'clock on that day read 48.53 feet above the low-water mark of 1872, which is the zero of the gauge. This zero is 2.4 feet above sea level. This remarkable stage of the river was 1.53 feet above high-water mark of 1874, and 2.26 feet above high-water mark of 1867. The high-water marks of the years 1867, 1874, and 1882 are 46.27, 47.05, and 48.53 respectively. It will be seen from these figures that the flood intervals from 1867 to 1882 are 7 and 8 years, respectively; the rise of the flood surface for these periods, 0.78 and 1.48 feet.

The general character of the Old River water-way, and the effects of the periodic flow inward and outward, will doubtless be of intetest here. The period of change of flow is generally 3 days. The first sign manifest is a marked checking of the current in Old River, and a more marked degree of clearness in the water. These changes are very easily noticed on the first day. On the second day the current nearly ceases. On the third, the change of flow is found to have taken place; the current will be found as swift as usual, and the water will have the usual mud color. The direction of flow is, of course, governed by the relative stages of the Mississippi and the Atchafalaya, the Red River, of course, governing the Atchafalaya. The current is swifter when the flow is outward. The general effects of an inward flow are more injurious to the Old River water-way than an outward flow is, and for this reason, that when the flow is inward, the current is greatly diminished and the percentage of sediment in the water is visibly greater.

These two ruling elements, which under the circumstances act in unison, cause a more rapid fill, while the checking of the current diminishes the scouring that characterizes an outward flow.

Turnbull Island is also an obstacle to the flow through Old River, and at flood stages it forms the basis of marked fills all the way around the island. It is in fact the nucleus of all the sand-bars in the vicinity. The effects of an outward flow are more beneficial to navigation than an inward flow, though at certain points, which will be described presently, it has a damaging effect. It is in general more beneficial, as the current is more rapid, and the percentage of sediment in the water is much smaller, as Red River water has, I think, a smaller percentage of sediment than Mississippi water. The deep-red color of the former is due to matter held in solution rather than that held in suspension. These are the things which make an outward flow favorable to navigation. The shoal places in Old River are three in number, and are situated as follows: At Barbre's crossing, in vicinity of Ash Cabin Bend, and at the Mississippi mouth of Old River. The causes that have produced this shoaling I consider to have been as follows: At the Barbre crossing the shoaling is due to the checking of the current of Red River as it sweeps around the bend where it enters Old River. In turning this bend, it loses a great part of its velocity, which it cannot possibly recover until it gets some distance beyond Barbre's crossing. The effect of this is the piling up of the sediment which the river has pushed to this point, and which the loss of velocity prevents from being carried farther. The deposit from the water itself is also augmented, owing to the slackening up of the current. The flow either way from Old River causes a fill at this crossing, and for this reason, that when the flow is outward the current is checked in the Red River bend as before; when the flow is inward the current is checked near the turn at the Ash Cabin; and when it gets to Barbre's crossing, it encounters Red River, which is moving nearly at right angles to it. So it is seen both streams meet at this point in a somewhat exhausted condition. Their forces are so nearly equal that equilibrium is nearly produced, which action, as is obvious, causes the fill or shoaling referred to.

The equalization of the forces of the water at this point is verified by the well-defined color line that is always seen at this point. The shoaling near the Ash Cabin is due to the decrease of velocity caused by Old River encountering the bends it meets before it reaches this point. The fill is greater at this point when the current is inward, as the arm of the bend with reference to an inward flow is more abrupt. The shoaling at the mouth is due wholly to an inward flow. The large volume of Mississippi water that sweeps around the turn at Carr's Point carries with it a vast volume of sediment, which it leaves at the shoal section referred to for want of sufficient velocity to carry it farther. The loss of velocity in this case is much greater than in any of the others mentioned; the fill is in consequence much greater. The steamboat channel at entrance of Old River attests the great force and action of the water as it sweeps around this point. This channel, just before you enter Old River, is nearly at right angles to the Old River Channel. On both sides of it, immense sand reefs exist. This channel resembles a canal more than it does a natural passage.

This channel is due to the action of the maximum thread of the current, which sweeps around the point at the mouth with a tremendous force and passes the mouth without entering. It is this portion of the current that produces the channel at the entrance of Old River. This point of Old River is benefited materially by an outward flow, as the volume of water coming out scours more rapidly. The outward volume pushes the Mississippi water as it rounds Carr's Point farther toward the left bank; *i. e.*, it has that tendency. This action causes the bar at the point of Old River (the nucleus of which is Carr's Point) to make rapidly down stream. Its make is due wholly to the meeting of the two rivers at this point when the flow is outward. By meeting they lose a large percentage of their velocity, and thus increase the sedimentary deposit at this point. This bar made about 300 feet down stream last year.

Should the flow continue outward from Old River without changing, and low stages of the river predominate for any great length of time, this bar would eventually work its way down stream and connect with the main bank of the Mississippi below Torras's, and thus close up Old River at low water entirely. This section of the country, and more especially that within a radius of 10 miles from the center of Turnbull's Island, is a very interesting one, and is a wide field for investigation at the present time, as it no doubt contains the unknown quantities that make the problem of the change of the Mississippi channel at the present time a vague uncertainty.

Respectfully submitted.

JOHN EWENS,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

Discharge observations, Red River Landing, La.

In this tabulation the gauge readings, water area, maximum depth, width, mean velocity, discharge, direction and force of wind, temperature of air and water, and method were copied from note-books Nos. 831-835, 839-844, 854.

Rise or fall between any two days was obtained by taking the difference between the gauge readings on those days.

Scour or fill between any two days was obtained thus: Take the difference between the water area on the first day, counted for rise or fall for the time considered, and the water area of the second day. If the area of the second day is the larger, the difference is scour; and if the smaller, this difference is fill.

Datum was taken at a gauge reading of 48.5 feet, and surface width of 3,918 feet, on March 27.

Datum area is the water area of March 27 and = 234,480 square feet.

Subsequent datum areas were obtained by successively adding and subtracting the scours and fills.

Datum areas between December 14 and March 27, 1882, were obtained by working backward from March 27.

Mean depth was obtained by dividing the water area by the water width.

Mean datum depth was obtained by dividing datum area by datum width.

MISSISSIPPI RIVER.

Discharge observations at Red River Landing, La.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.		Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.									Air.	Water.		
			Water.	Below datum.	Mean.	Mean datum.	Maximum.										
1881.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*			°	°		
Dec. 14	30.29		149,960	219,147	40.02	55.93	58.0	3,747		4.417	662,484	VI	5	50		D. F.	M=Meter.
15	29.66	−0.63															R=Rod floats.
16	28.79	−0.87	147,120	221,919	39.38	56.64	59.2	3,736	+ 2,772	4.370	642,915	VII	2	44		D. F.	D. F=Double floats.
17	27.85	−0.94	141,840	220,147	38.05	56.19	56.0	3,728	− 1,772	4.267	605,277	VII	3	47		D. F.	
18	26.91	−0.94															
19	25.95	−0.96	133,120	218,487	35.94	55.76	57.0	3,704	− 1,660	4.257	566,703	XI	3	59		D. F.	
20	24.97	−0.98															
21	24.17	−0.80															
22	23.55	−0.62	123,680	217,921	33.51	55.62	53.1	3,691	− 566	3.961	489,783	IV	4	45		D. F.	
23	23.15	−0.40															
24	22.95	−0.20	119,520	215,973	32.47	55.12	58.0	3,681	− 1,948	4.082	487,938	VI	2	47		D. F.	
25	23.11	+0.16															
26	23.67	+0.56															
27	24.61	+0.94	125,760	216,069	34.02	55.15	55.3	3,697	+ 116	4.148	521,674	XI	3	55		R.	
28	25.72	+1.11															
29	26.80	+1.08															
30	27.98	+1.18	141,840	219,648	37.99	53.06	56.7	3,734	+ 3,559	4.514	640,327	V	4	46		D. F.	
31	29.00	+1.02	146,240	220,241	39.20	56.21	56.1	3,731	+ 593	4.302	629,164	III	4	48		D. F.	
1882.																	
Jan. 1	30.16	+1.16															
2	30.84	+0.68															
3	31.59	+0.75	159,600	223,914	42.57	57.15	62.1	3,749	+ 3,673	4.519	720,892	XII	4	52		D. F.	
4	32.19	+0.60															
5	32.69	+0.50	160,720	220,906	42.78	56.38	59.0	3,757	− 3,008	4.661	749,035	XII	2	68		D. F.	
6	33.02	+0.33															
7	33.50	+0.48															
8	34.17	+0.67															
9	34.58	+0.41															
10	34.78	+0.20															
11	35.11	+0.33															
12	35.28	+0.17															
13	35.50	+0.22															
14	35.69	+0.19															
15	35.87	+0.18															

	16	36.05	+0.18															
	17	36.29	+0.24															
	18	36.49	+0.20															
	19	36.65	+0.16	175,760	221,076	46.83	56.48	66.5	3,758	+ 170	5.449	987,715	VI	3	39		D. F.	
	20	36.96	+0.31	176,080	220,282	46.87	56.21	67.8	3,757	− 844			VI	3	45		D. F.	
	21	37.59	+0.63	177,791	219,575	47.26	56.04	66.0	3,762	− 657	5.906	1,050,024	VI	3	53		D. F.	
	22	37.73	+0.14															
	23	37.87	+0.14	176,480	217,214	47.25	55.44	68.0	3,735	− 2,361	5.725	1,010,411	XII	4	44		D. F.	
	24	38.17	+0.30	179,760	219,368	47.67	55.99	66.4	3,771	− 2,154	5.590	1,004,873	IX	4	63		D. F.	
	25	38.39	+0.22															
	26	38.60	+0.21	182,720	220,708	48.62	56.33	67.7	3,758	+ 1,340	5.509	1,006,613	XII	4	70		D. F.	
	27	38.87	+0.27															
	28	39.10	+0.23	188,080	224,186	49.88	57.22	67.5	3,771	+ 3,478	5.711	1,074,031	VIII	4	62		D. F.	
	29	39.47	+0.37															
	30	39.65	+0.18															
	31	39.84	+0.19															
Feb.	1	39.94	+0.10															
	2	39.98	+0.04	191,440	224,228	50.79	57.23	70.0	3,769	+ 42	5.691	1,089,579	VIII	3	51	44	D. F.	
	3	40.23	+0.25															
	4	40.49	+0.26	195,014	225,879	51.67	57.65	69.0	3,774	+1,651	6.094	1,188,491	VI	4	51	45	D. F.	
	5	40.66	+0.17															
	6	40.81	+0.15	190,480	220,137	50.41	56.19	70.0	3,779	−5,742	6.128	1,167,260	XI	3	54	46	D. F.	
	7	40.91	+0.10	195,476	224,755	51.64	57.36	69.0	3,785	+4,618	6.224	1,216,624	X	3	59	47	D. F.	
	8	41.12	+0.21	193,040	221,525	51.11	56.54	68.0	3,777	−3,230	6.262	1,208,903	I	5	63	48	D. F.	
	9	41.27	+0.15	196,820	224,238	51.92	57.28	69.0	3,781	+2,713	5.361	1,052,566	V	4	54	48	M.	
	10	41.49	+0.22	192,160	219,247	50.88	55.96	69.0	3,777	−4,991	5.721	1,099,393	XI	3	53	50	M. D. F.	
	11	41.60	+0.11	194,280	220,951	51.36	56.39	70.0	3,783	+1,704	5.610	1,089,972	XI	4	61	51	D. F.	
	12	41.71	+0.11															
	13	41.89	+0.18															
	14	42.07	+0.18	196,400	221,292	51.85	56.48	71.0	3,788	+ 341	5.925	1,162,751	XII	2	55	54	D. F.	
	15	42.24	+0.17	197,120	221,369	52.15	56.50	70.5	3,780	+ 77	5.895	1,162,059	XII	3	63	54	D. F.	
	16	42.35	+0.11															
	17	42.53	+0.18	200,880	224,032	53.02	57.18	71.4	3,785	+2,663	5.885	1,162,091	V	3	71	56	D. F.	
	18	42.65	+0.12	204,080	226,778	53.90	57.88	71.8	3,786	+2,746	5.747	1,172,742	XI	5	70	56	D. F. R.	
	19	42.80	+0.15															
	20	42.96	+0.16															
	21	43.19	+0.23	207,200	227,858	54.68	58.16	73.0	3,789	+1,975	5.856	1,213,404	VI	5	51	58	D. F.	
	22	43.30	+0 11	209,840	230,076	55.35	58.72	72.5	3,791	+2,223	5.704	1,196,874	VI	4	50	58	D. F,	
	23	43.42	+0.12	209,920	229,701	55.84	58.63	73.4	3,793	− 375	5.845	1,227,062	V	4	59	58	D. F.	
	24	43.61	+0.19	209,360	228,417	54.65	58.30	71.5	3,831	−1,284	5.768	1,207,497	VII	3	57	58	D. F.	
	25	43.80	+0.19															
	26	43.95	+0.15															
	27	44.14	+0.19	214,000	231,021	55.54	58.96	72.0	3,853	+2,604	5.738	1,227,923	XI	30–3	65	58	D. F.	
	28	44.33	+0.19	217,320	233,609	56.40	59.62	72.0	3,853	+2,588	5.691	1,236,683	I	30–3	67	58	D. F.	
Mar.	1	44.62	+0.29	213,920	229,091	55.46	58.47	72.0	3,857	−4,518			VII	3	63	58	M.	Incomplete data.
	2	44.82	+0.20	218,880	233,274	55.99	59.54	73.5	3,909	+4,183	5.629	1,232,031	XI	2	60	59	M.	
	3	45.09	+0.27	219,240	232,580	56.23	59.36	74.0	3,899	− 694	5.686	1,246,667	XI	2	66	60	M.	
	4	45.30	+0.21															
	5	45.48	+0.18															
	6	45.76	+0.28															
	7	45.95	+0.19	228,440	238,420	58.36	60.85	76.5	3,914	+5,840	5.824	1,330,327	VII	5	60	62	D. F.	
	8	46.24	+0.29	229,600	238,445	58.66	60.86	76.0	3,914	+ 25	5.814	1,334,914	I	5	61	62	D. F.	

MISSISSIPPI RIVER.—*Discharge observations at Red River Landing, La.*—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.		Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.									Air.	Water.		
			Water.	Below datum.	Mean.	Mean datum.	Maximum.										
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*			°	°		
Mar. 9	46.52	+0.28	230,080	237,829	58.78	60.70	75.8	3,914	− 616	5.913	1,360,508	V	3	60	62	D. F.	
10	46.78	+0.26	230,160	236,891	58.80	60.46	76.8	3,914	− 938	6.070	1,396,955	VII	4	57	62	D. F.	
11	46.87	+0.09	231,040	237,419	59.18	60.60	77.2	3,904	+ 528	5.935	1,371,260	XII	2	62	62	D. F.	
12	47.03	+0.16															
13	47.24	+0.21	233,240	238,175	59.74	60.79	77.5	3,904	+ 756	6.037	1,408,006	VII	3	67	61	D. F.	
14	47.30	+0.06	233,280	237,981	59.75	60.74	78.5	3,904	− 194	6.003	1,407,183	XI	5	72	63	D. F.	
15	47.38	+0.08	233,600	237,988	59.62	60.74	78.5	3,918	+ 7	6.281	1,467,020	XII	2	75	66	D. F.	
16	47.50	+0.12	237,600	241,518	60.64	61.64	79.0	3,918	+3,530	6.077	1,443,864	XII	2	79	67	D. F.	
17	47.56	+0.06	237,760	241,443	60.68	61.62	79.0	3,918	− 75	6.174	1,467,917	XII	4	79	67	D. F.	
18	47.63	+0.07	234,080	237,489	59.74	60.61	79.0	3,918	−3,954	6.201	1,451,026	XII	5	74	67	D. F.	
19	47.70	+0.07															
20	47.77	+0.07	234,560	237,420	59.87	60.60	79.0	3,918	− 69	6.002	1,407,755	I	4	74	68	D. F.	
21	47.98	+0.21															
22	48.02	+0.04															
23	48.12	+0.10	231,760	233,249	59.15	59.53	77.0	3,918	−4,171	6.087	1,410,753	V	4	66	70	D. F.	
24	48.25	+0.13	234,320	235,300	59.81	60.06	78.0	3,918	+2,051	6.290	1,478,808	VI	4	68	70	D. F.	
25	48.30	+0.05	231,040	231,824	58.97	59.17	77.5	3,918	−3,476	6.360	1,469,116	XII	4	65	67	D. F.	
26	48.46	+0.16															
27	48.50	+0.04	234,480	234,480	59.85	59.85	79.0	3,918	+2,656	6.222	1,458,902	V	2	74	76	D. F.	
28	48.43	−0.07	237,520	237,794	60.92	60.69	80.5	3,899	+3,314	6.458	1,533,950	VII	2	62	64	D. F.	
29	48.39	−0.04	237,360	237,790	60.88	60.69	80.2	3,899	− 4	6.484	1,539,145	VI	4	65	62	D. F.	
30	48.36	−0.03	234,160	234,707	60.06	59.77	80.0	3,899	−3,083	6.427	1,504,922	VI	1	74	66	D. F.	
31	48.32	−0.04	235,360	236,063	60.36	60.07	80.5	3,899	+1,356	6.778	1,595,310	VII	1	74	66	D. F.	
Apr. 1	48.25	−0.07															
2	48.23	−0.02															
3	48.09	−0.14	236,240	237,840	60.59	60.70	78.0	3,899	+1,777	6.448	1,523,198	0	0	74	66	D. F.	
4	47.95	−0.14	235,440	237,586	60.38	60.64	77.0	3,899	− 254	6.063	1,427,409	X	30–2	67	66	D. F.	
5	47.83	−0.12	233,680	236,294	59.93	60.31	77.0	3,899	−1,292	6.061	1,416,842	X	30–2	69	66	D. F.	
6	47.70	−0.13	234,400	237,521	60.12	60.62	77.5	3,899	+1,227	6.336	1,485,310	X	30–1	70	66	D. F.	
7	47.56	−0.14	233,440	237,107	59.87	60.52	79.0	3,899	− 414	6.256	1,460,453	X	30–2	70	66	D. F.	
8	47.39	−0.17	236,240	240,570	60.59	61.40	78.5	3,899	+3,463	5.978	1,412,243	X	4	72	67	D. F.	
9	47.23	−0.16															
10	47.03	−0.20	237,120	242,850	61.18	61.98	79.5	3,876	+2,280	6.012	1,425,566	0	0	73	67	D. F.	
11	46.96	−0.07															
12	47.00	+0.04	237,200	243,046	61.20	62.08	78.7	3,876	+ 196	6.333	1,502,218	IX	30–1	70	68	D. F.	
13	46.93	−0.07	240,240	246,357	61.98	62.88	79.5	3,876	+3,311	6.337	1,522,479	VI	7	58	66	D. F.	
14	46.77	−0.16	242,240	248,977	62.50	63.55	80.0	3,876	+2,620	6.074	1,471,340	VI	7	57	66	D. F.	

	15	46.60	−0.17	244,560	251,956	63.10	64.81	79.8	3,876	+2,979	5.932	1,450,790	VII	7	59	64	D. F.
	16	46.47	−0.13														
	17	46.28	−0.19	245,280	253,916	63.28	64.81	79.8	3,876	+1,960	5.550	1,361,346	VII	30–1	68	63	D. F.
	18	46.14	−0.14	243,280	252,459	62.77	64.44	78.6	3,876	−1,457	5.640	1,372,014	XII	2	74	64½	D. F.
	19	46.02	−0.12	244,800	254,444	63.16	64.94	79.7	3,876	+1,985	5.506	1,347,772	X	2	71	66	D. F.
	20	45.93	−0.09	247,120	257,113	63.76	65.62	79.2	3,876	+2,669	5.514	1,362,649	VIII	30–1	78	64	D. F.
	21	45.81	−0.12	247,280	257,788	63.88	65.78	80.0	3,871	+ 625	5.516	1,364,111	X	2	74	65	D. F.
	22	45.77	−0.04	248,400	259,013	64.17	66.11	79.5	3.871	+1,275	5.483	1,361,906	VIII	30–5	73	65	D. F.
	23	45.69	−0.08														
	24	45.61	−0.08	247,520	258,752	63.94	66.04	78.7	3,871	− 261	5.515	1,305,451	X	2	73	66	D. F.
	25	45.52	−0.09	251,360	262,940	64.93	67.11	79.5	3,871	+4,188	5.206	1,308,545	X	2	71	66	D. F.
	26	45.35	−0.17	250,160	262,308	64.62	66.97	78.6	3,871	− 542	5.266	1,317,374	XI	2	70	67	D. F.
	27	45.28	−0.07	246,000	258,509	63.55	65.98	79.4	3,871	−3,889	5.353	1,316,928	XI	30–1	72	67	D. F.
	28	45.12	−0.16	245,440	258,568	63.40	65.09	79.3	3,871	+ 59	5.356	1,314,596	X	1	70	68	D. F.
	29	45.00	−0.12	244,560	258,153	63.18	65.89	78.7	3,871	− 415	5.171	1,264,554	VII	30–5	75	67	D. F.
	30	44.85	−0.15														
May	1	44.71	−0.14	239,600	254,316	61.90	64.91	79.0	3,871	−3,887	5.208	1,246,719	XII	2	67	67	M. & D. F.
	2	44.59	−0.12	239,200	254,381	61.79	64.93	79.0	3,871	+ 65	5.121	1,235,013	XII	1	68	69	D. F.
	3	44.34	−0.25	237,600	253,749	61.88	64.76	79.0	3,871	− 632	5.082	1,207,592	II	30–2	78	69	D. F.
	4	44.24	−0.10	238,720	255,256	61.67	65.15	77.0	3,871	+1,507	5.402	1,289,490	II	1	76	65	D. F.
	5	44.09	−0.15	238,400	255,517	61.59	65.22	77.2	3,871	+ 261	5.161	1,230,309	XI	2	74	67½	D. F.
	6	43.95	−0.14	238,160	255,819	61.52	65.29	78.0	3,871	+ 302	5.217	1,242,592	VII	5	76	65½	D. F.
	7	43.77	−0.18														
	8	43.88	+0.11	238,240	256,170	61.54	65.38	78.0	3,871	+ 351	5.045	1,201,889	XII	6	74	66	D. F.
	9	43.64	−0.24														
	10	43.59	−0.05	237,360	256,418	61.32	65.44	77.5	3,871	+ 243	4.908	1,163,865	XII	4	73½	65	D. F.
	11	43.28	−0.31	236,480	256,718	62.66	65.52	76.3	3,774	+ 305	4.848	1,145,333	IV	3	69	67	D. F.
	12	43.07	−0.21	235,600	256,630	62.56	65.50	76.8	3,766	− 88	5.312	1,251,457	IV	2	68	67	M.
	13	42.92	−0.15	234,240	255,835	62.20	65.30	76.3	3,766	− 795	4.969	1,163,882	IV	5	66	67	M.
	14	42.78	−0.14														
	15	42.64	−0.14	236,480	259,129	62.84	66.14	77.5	3,763	+3,294	5.157	1,219,465	VI	2	65	66	M.
	16	42.49	−0.15	235,760	258,973	62.65	66.10	78.0	3,763	− 156	5.008	1,180,768	VII	1	74	67	M.
	17	42.37	−0.12	235,600	259,264	62.64	66.17	77.0	3 761	+ 291	5.059	1,191,831	VII	1	68	69	M.
	18	42.25	−0.12	236,560	260,675	62.90	66.53	76.5	3,761	+1,411	5.117	1,210,493	XI	2	78	65	M.
	19	42.10	−0.15	235,480	260,159	62.59	66.40	77.0	3,762	− 516	5.114	1,204,132	XI	5	72	65	M.
	20	41.91	−0.19	234,240	259,634	62.26	66.27	76.7	3,762	− 525	5.018	1,175,341	XI	4	70	65	M.
	21	41.92	+0.01														
	22	41.86	−0.06	233,040	258,622	61.95	66.01	75.7	3,762	−1,012	4.778	1,113,540	VI	3	66	65	D. F.
	23	41.77	−0.09	232,160	258,081	61.73	65.87	75.4	3,761	− 541	5.014	1,164,070	VII	30–4	67	68	M.
	24	41.61	−0.16	231,600	258,128	61.61	65.88	75.0	3,759	+ 42	4.950	1,146,364	XI	3	71	65	M.
	25	41.50	−0.11	231,280	258,216	61.53	65.91	75.2	3,759	+ 93	4.939	1,142,194	VIII	3	75	66	M.
	26	41.43	−0.07	229,120	256,319	60.95	65.42	75.3	3,759	−1,897	4.984	1,142,017	XI	3	77	67	M.
	27	41.38	−0.05	230,800	258,187	61.42	65.90	75.0	3,758	+1,868	5.004	1,155,019	XII	3	71	69	M.
	28	41.36	−0.02														
	29	41.34	−0.02	229,360	256,897	61.02	65.57	75.2	3,759	−1,290	4.987	1,132,356	VIII	1	76	68	M.
	30	41.31	−0.03														
	31	41.42	+0.11	231,360	258,506	61.55	66.00	75.2	3,759	+1,699	4.918	1,137,809	XI	5	69	67	M.
June	1	41.44	+0.02	232,240	259,401	61.78	66.21	76.0	3,759	+ 805	4.900	1,138,053	VI	4	75	68	M.
	2	41.45	+0.01	233,760	260,888	62.19	66.59	76.1	3,759	+1,482	4.998	1 168,341	X	30–2	75	69	M.
	3	41.41	−0.04	233,120	260,893	62.02	66.46	75.5	3,759	− 490	4.827	1,125,364	I	30–2	79	71	M.
	4	41.40	+0.01														
	5	41.42	+0.02	232,240	259,475	61.68	66.23	76.0	3,765	− 918	4.725	1,097,308	VIII	30–4	75	69	M.

MISSISSIPPI RIVER.—*Discharge observations at Red River Landing, La.*—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.	Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.								Air.	Water.		
			Water.	Below datum.	Mean.	Mean datum.	Maximum.									
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*		°	°		
Sept. 2	13.35	−0.69	140,273	253,565	38.08	64.72	47.5	3,684	− 757	2.615	366,894	VI 4	82	83	M.	
3	17.73	−0.62														
4	17.18	−0.55	136,310	253,909	37.06	64.81	45.8	3,678	+ 344	2.638	359,788	VII 3–6	......	84	M.	
5	16.17	−1.01	134,362	255,675	36.55	65.26	46.0	3,676	+1,766	2.643	355,168	VIII 4	86	84	M.	
6	16.11	−0.06														
7	15.56	−0.55	129,173	252,726	35.22	64.50	45.0	3,668	−2,949	2.587	334,233	X 3	87	83	M.	
8	15.32	−0.24	128,207	252,642	34.95	64.48	44.6	3,668	− 86	2.563	328,566	VI–X 3–5	76	83	M.	
9	15.00	−0.32														
10	14.84	−0.16														
11	14.50	−0.34	123,973	251,409	33.90	64.17	43.5	3,657	−1,231	2.458	304,757	VI 2	79	81	M.	
12	14.23	−0.27	122,186	250,609	33.42	63.96	43.0	3,656	− 800	2.540	310,420	X 3	79	80	M.	
13	14.04	−0.19	121,761	250,879	33.30	64.03	42.6	3,657	+ 270	2.532	308,362	X 3	94	81	M.	
14	13.98	−0.06														
15	13.98	0.00	122,029	251,366	33.37	64.16	42.7	3,657	+ 487	2.448	298,781	X 3	83	79	M.	
16	14.00	+0.02	121,112	250,376	33.12	63.90	43.0	3,657	− 990	2.502	303,034	VII 3	90	79	M.	
17	13.92	−0.08														
18	13.83	−0.09	119,949	249,834	32.08	63.77	42.6	3,658	− 542	2.463	295,414	XII 4	84	80	M.	
19	13.71	−0.12	120,274	250,597	32.96	63.96	41.9	3,649	+ 763	2.464	296,393	X 3	87	80	M.	
20	13.51	−0.20	119,587	250,640	32.75	63.97	42.3	3,651	+ 43	2.504	299,503	X 4	85	80	M.	
21	13.34	−0.17														
22	13.02	−0.32														
23	12.70	−0.32	114,874	248,882	31.51	63.52	42.0	3,646	−1,758	2.456	282,135	VII 5	68	78	M.	
24	12.62	−0.08														
25	12.82	+0.20	115,298	248,869	31.63	63.52	42.0	3,645	− 13	2.468	284,667	VIII 4	77	77	M.	
26	13.20	+0.38	117,335	249,521	32.18	63.69	42.0	3,646	+ 652	2.514	295,596	VII 4	76	76	M.	
27	13.70	+0.50														
28	14.11	+0.41	122,169	251,032	33.40	64.07	43.0	3,658	+1,511	2.609	318,800	XII 6	76	76	M.	
29	14.38	+0.27														
30	14.41	+0.03	122,236	250,001	33.40	63.81	43.3	3,660	−1,031	2.456	300,814	XI 3–6	79	77	M.	
Oct. 1	14.33	−0.08														
2	13.90	−0.43														
3	13.43	−0.47	119,537	250,884	32.74	64.08	43.3	3,651	+ 883	2.392	287,934	VII 3	80	76	M.	
4	12.86	−0.57	117,550	250,978	32.21	64.06	42.0	3,650	+ 94	2.320	272,665	{VII} {XII} 4	78	76	M.	
5	12.30	−0.56	115,298	250,769	31.61	63.00	42.0	3,648	− 209	2.298	265,000	XI 3	81	86	M.	
6	11.70	−0.60	112,462	250,121	30.86	63.84	41.5	3,644	− 648	2.282	256,649	X 5	81	76	M.	
7	11.10	−0.60	109,812	249,656	30.17	63.72	41.0	3,640	− 465	2.300	252,393	X 5	79	76	M.	

	8	10.64	−0.46														
	9	10.28	−0.36	107,887	250,714	29.67	63.99	40.0	3,636	+1,058	2.177	234,425	IV	4	86	76	M.
	10	9.85	−0.43	105,749	250,186	29.12	63.84	40.0	3,631	− 576	2.145	226,634	VII	4	81	76	M.
	11	9.65	−0.20	106,599	251,714	29.36	64.25	40.0	3,631	+1,576	2.157	229,933	VIII	3	81	76	M.
	12	9.43	−0.22														
	13	9.45	+0.02	104,924	250,765	28.90	64.00	39.0	3,631	− 949	2.141	224,679	XI VI	4	81	76	M.
	14	9.43	−0.02	103,975	249,889	28.59	63.78	39.0	3,637	− 876	2.228	231,735	VIII	4	74	75	M.
	15	9.39	−0.04														
	16	9.24	−0.15	101,910	248,515	28.04	63.48	38.0	3,635	−1,374	2.196	223,833	XI	4	79	75	M.
	17	9.18	−0.06	102,085	248,858	28.07	63.52	38.0	3,636	+ 343	2.296	234,282	VIII	4	77	74	M.
	18	9.20	+0.02														
	19	9.20	+0.00														
	20	9.30	+0.10														
	21	9.35	+0.15	101,578	247,778	27.94	63.24	39.5	3,635	−1,080	2.225	225,988	VI	4	68	72	M.
	22	9.47	+0.12														
	23	9.58	+0.11	103,586	248,955	28.50	63.54	39.8	3,635	+1,177	2.396	248,240	VI	4	67	71	M.
	24	9.73	+0.15														
	25	9.94	+0.21	110,662	254,722	30.42	65.01	42.6	3,638	+5,767	2.370	262,855	XI	4	69	70	M.
	26	10.19	+0.25	102,799	245,949	28.25	62.77	39.4	3,639	−8,778	2.442	251,097	XI	2–5	74	70	M.
	27	10.45	+0.26	101,837	244,040	27.96	62.29	40.4	3,642	−1,909	2.472	251,842	XI	3	71	70	M.
	28	10.53	+0.08	104,300	246,212	28.64	62.84	40.7	3,642	+2,172	2.442	254,697	I	3	73	70	M.
	29	10.55	+0.02														
	30	10.47	−0.08	103,087	245,217	28.31	62.56	40.2	3,641	− 995	2.423	250,705	XI	4		69	M.
	31	10.41	−0.06														
Nov.	1	10.35	−0.06	103,436	246,003	28.42	62.79	40.8	3,640	+ 786	2.530	261,766	I	2	78	70	M.
	2	10.16	−0.19														
	3	9.94	−0.22	101,312	245,871	27.83	62.63	40.0	3,640	− 632	2.408	244,024	VII	5	70	69	M.
	4	9.79	−0.15	98,674	243,279	27.11	62.09	39.8	3,640	−2,092	2.447	241,584	VII	2	66	69	M.
	5	9.70	−0.09														
	6	9.68	−0.02	99,211	244,216	27.29	62.33	38.0	3,635	+ 987	2.425	240,685	I	3–5	69	69	M.
	7	9.66	−0.02	99,887	244,965	27.48	62.52	39.0	3,635	+ 749	2.416	241,363	XII	3	70	68	M.
	8	9.66	0.00	101,824	246,902	28.01	63.02	40.5	3,635	+1,987	2.462	250,940	XII	3	71	69	M.
	9	9.66	0.00														
	10	9.70	+0.04	102,050	246,983	28.07	63.04	41.0	3,635	+ 81	2.502	255,374	XII	4	69	68	M.
	11	9.82	+0.12	101,700	246,197	27.96	62.84	41.0	3,637	− 786	2.381	242,166	I	5	74	68	M.
	12	10.07	+0.25														
	13	10.23	+0.16														
	14	10.33	+0.10	105,549	248,189	28.96	63.35	40.5	3,645	+1,992	2.470	260,753	VII	5	44	65	M.
	15	10.40	+0.07	104,962	247,847	28.80	63.13	40.0	3,645	− 842	2.448	256,945	VII	3	45	65	M.
	16	10.49	+0.09														
	17	10.74	+0.25	104,637	245,782	28.67	62.78	41.5	3,650	−1,565	2.567	268,626	VII	5	60	68	M.
	18	10.93	+0.19														
	19	11.31	+0.38														
	20	11.83	+0.52	108,299	245,404	29.65	62.65	41.2	3,653	− 818	2.652	287,295	V	6	44	68	M.
	21	12.20	+0.37	111,261	247,074	30.46	63.06	42.4	3,653	+1,610	2.628	292,445	VIII	4	41	62	M.
	22	12.60	+0.40	112,324	246,675	30.71	62.96	42.0	3,658	− 899	2.718	305,339	XI	4	51	66	M.
	23	12.98	+0.38	112,949	246,092	30.85	62.81	43.0	3,661	− 588	2.757	301,652	XII	4	60	67	M.

Discharge observations, Atchafalaya River.

The computations for the discharge of the Atchafalaya River were made in the following manner:

The areas were obtained by plotting the sections on cross-section paper, locating the position of velocity observations, then dividing the section into partial areas, and counting the small squares in each area; thus giving to each velocity an area, unless two or more velocities were taken very close together, in which case an area was given to the mean of this group of velocities.

The sum of these partial areas being the total area of section.

The discharge for partial areas was obtained by multiplying the area by its velocity.

The total discharge being the sum of the partial discharges thus obtained.

The mean velocity was obtained by dividing the total discharge by the total area.

The mean depth is obtained by dividing the area by the water width.

The maximum depth is the deepest actual sounding taken.

Scour or fill is the difference in sectional area obtained by actual area difference compared with difference due to change of gauge; 51 feet was taken as datum gauge-reading, being .13 foot above highest gauge-reading when observations were taken; the difference in area due to this difference in gauge was added to the water area of March 28; the area thus obtained being used as the datum area.

The other datum areas were obtained by successively adding or subtracting the scours and fills.

Mean datum depth was obtained by dividing the datum area by the datum width, 1,030 feet.

Owing to the recorded gauge-readings in the note-books being very unsatisfactory, they were discarded and a set of readings interpolated from the Barbres Landing gauge in the following manner.

The gauge is at the head of the Atchafalaya, about 1,500 feet above the discharge section. A curve was plotted on profile paper from this gauge, and readings were interpolated for 4 p. m. of each day, which time is the mean time of daily observations.

The difference in readings between the gauge at section and Barbres gauge was determined (1.1 feet). This correction was applied to readings on Barbres gauge.

The computations up to August 16 were made in the field; after that date in the office.

A discharge curve was plotted and several of the observations farthest from the line were recomputed; some of them found in error, others checking closely.

A. H. WEBER.

Discharge observations at Atchafalaya River.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.		Tempera-ture, Fahr.		Method.	Remarks.
	Read-ing.	Rise or fall in the preced-ing 24 hours.	Area.		Depth.									Air.	Water.		
			Water.	Below datum.	Mean.	Mean datum.	Maxi-mum.										
1881.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*	*O'clock.*	*Force.*	°	°		
Dec. 12	31.20																
13	30.90	−0.30	24,860	41,915	33.6	40.7	68.0	739.7		4.069	101,145.6	III	4			D. F.	Double floats.
14	30.45	−0.45															
15	29.90	−0.55	22,500	40,293	30.6	39.1	64.0	735.1	−1,622	3.592	80,832.8	IX	5			D. F.	
16	29.13	−0.77															
17	28.35	−0.78															
18	27.30	−1.05															
19	26.40	−0.90															
20	25.50	−0.90															
21	24.73	−0.77	18,660	39,885	31.4	38.7	60.1	592.7	− 408	3.263	60,890.7					D. F.	
22	24.14	−0.59															
23	23.80	−0.34	18,320	40,093	31.2	38.9	60.0	586.4	+ 208	2.843	52,100.0	V	3			D. F.	
24	23.72	−0.08															
25	23.90	+0.18															
26	24.32	+0.42	18,520	39,984	30.6	38.8	59.6	604.6	− 109	3.118	57,752.6	XII	4			D. F.	
27	25.17	+0.85															
28	26.30	+1.13	19,320	39,566	30.8	38.4	62.0	625.4	− 418	3.435	66,377.4	XI	3			D. F.	
29	27.27	+0.97	19,080	38,714	30.0	38.5	64.1	635.7	− 852	3.372	64,354.8	V	5			D. F.	
30	28.10	+0.83															
31	29.05	+0.95															
1882.																	
Jan. 1	29.85	+0.80															
2	30.60	+0.75															
3	31.40	+0.80															
4	31.95	+0.55	25,140	41,539	33.6	40.3	69.0	746.1	+2,825	4.036	101,477.2					D. F.	
5	32.40	+0.45															
6	32.85	+0.45	25,160	40,885	33.4	39.7	67.0	751.8	− 654	3.558	89,402.0					D. F.	Rain-fog-drift. Observation doubtful.
7	33.35	+0.50															
8	33.92	+0.57															
9	34.35	+0.43															
10	34.75	+0.40	26,680	40,932	33.8	39.7	64.0	790.8	+ 47	4.172	111,316.4	XII	5			D. F.	
11	35.10	+0.35															
12	35.22	+0.12	27,380	41,253	33.5	40.0	67.0	815.1	+ 321	4.246	116,241.7	XII	3			D. F.	and logs. Observation taken with difficulty.
13	35.60	+0.38															
14	35.95	+0.35															
15	36.20	+0.25															

Discharge observations at Atchafalaya River—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.		Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.												
			Water.	Below datum.	Mean.	Mean datum.	Maximum.							Air.	Water.		
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*	*O'clock.*	*Force.*	°	°		
Jan. 16	36.45	+0.25															
17	36.80	+0.35															
18	37.02	+0.22															
19	37.23	+0.21															
20	37.65	+0.42															
21	38.04	+0.39															
22	38.30	+0.26															
23	38.60	+0.30															
24	39.00	+0.40															
25	39.23	+0.23															
26	39.45	+0.22															
27	39.75	+0.30															
28	40.00	+0.25															
29	40.27	+0.27															
30	40.60	+0.33															
31	40.83	+0.23															
Feb. 1	40.95	+0.12															
2	41.13	+0.18															
3	41.25	+0.12															
4	41.43	+0.18															
5	41.60	+0.17															
6	41.85	+0.25															
7	42.05	+0.20															
8	42.30	+0.25															
9	42.60	+0.30															
10	42.83	+0.23															
11	42.93	+0.10															
12	43.05	+0.12															
13	43.25	+0.20															
14	43.45	+0.20															
15	43.65	+0.20															
16	43.92	+0.27															
17	44.30	+0.38															
18	44.53	+0.23															
19	44.65	+0.12															
20	44.90	+0.25															

	21	45.15	+0.25	38,940	39,666	41.2	38.5	81.0	831.9	−1,567	4.393	166,080.6	V	5			D.F.
	22	45.40	+0.25														
	23	45.63	+0.23														
	24	45.73	+0.10														
	25	45.90	+0.17														
	26	46.20	+0.30														
	27	46.45	+0.25														
	28	46.75	+0.30														
Mar.	1	46.95	+0.20														
	2	47.20	+0.25														
	3	47.45	+0.25														
	4	47.70	+0.25														
	5	47.95	+0.25														
	6	48.15	+0.20	37,500	40,480	*36.7	39.3	85.0	1,022.0	+ 794	4.825	180,949.2	VII	5			D.F.
	7	48.20	+0.05	40,840	43,267	38.4	42.0	85.5	1,049.9	+2,787	5.023	202,575.5	VII	5			D.F.
	8	48.70	+0.50														
	9	48.95	+0.25														
	10	49.15	+0.20	39,340	41,270	37.4	40.0	87.5	1,049.9	−1,997	5.088	200,180.5	VII	4			D.F.
	11	49.35	+0.20														
	12	49.53	+0.18														
	13	49.63	+0.10	40,260	41,684	38.0	40.4	89.0	1,058.6	+ 414	5.961	240,814.3	V	3			D.F.
	14	49.73	+0.10	39,880	41,198	37.6	40.0	90.0	1,058.7	− 486	5.733	228,620.6	XI	4			D.F.
	15	49.83	+0.10	41,000	42,212	38.6	40.9	90.0	1,058.7	+1,014	5.617	230,318.2	VII	3			D.F.
	16	49.93	+0.10	39,840	40,946	37.6	39.5	90.3	1,058.7	−1,266	5.970	237,841.0	X	3			D.F.
	17	50.03	+0.10	40,480	41,481	38.5	40.2	87.0	1,050.0	+ 535	5.711	231,516.1	X	3			D.F.
	18	50.10	+0.07	40,080	41,008	38.5	39.8	90.0	1,040.0	− 473	5.603	224,555.1	II	4			D.F.
	19	50.10	0.00														
	20	50.15	+0.05														
	21	50.33	+0.18														
	22	50.43	+0.10	39,400	39,987	38.2	38.8	87.0	1,030.0	−1,021	5.486	216,161.8					D.F.
	23	50.53	+0.10	38,160	38,644	37.0	37.[illegible]	86.0	1,030.0	−1,343	6.192	236,286.6	II	4			D.F.
	24	50.63	+0.10	38,380	38,761	37.2	37.6	90.0	1,030.0	+ 117	5.446	209,008.7	III	4			D.F.
	25	50.73	+0.12														
	26	50.85	+0.12														
	27	50.97	+0.12														
	28	50.87	−0.10	38,150	38,284	37.9	37.1	90.0	1,030.0	− 477	6.921	264,050.0	XII½	3	62	67	D.F.
	29	50.80	−0.07	38,940	39,146	38.3	38.0	89.0	1,030.0	+ 862	7.047	274,498.0	VII	1	76	67	D.F.
	30	50.80	0.00	39,160	39,366	38.0	38.2	88.0	1,030.0	+ 220	6.907	270,480.0			79	67	D.F.
	31	50.77	−0.03	38,500	38,737	37.3	37.6	88.0	1,030.0	− 629	7.288	280,613.4	0	0	74	65	D.F.
Apr.	1	50.67	−0.10	38,080	38,420	36.9	37.3	86.0	1,030.0	−317	6.304	240,046.8	0	0	76	66	D.F.
	2	50.57	−0.10														
	3	50.47	−0.10	38,120	38,666	37.0	37.5	88.0	1,030.0	+246	5.007	190,858.2			74	65	D.F.
	4	50.37	−0.10	38,060	38,709	36.9	37.5	88.5	1,030.0	+ 43	6.497	247,290.9			71	66	D.F.
	5	50.27	−0.10														
	6	50.07	−0.20	37,900	38,858	36.7	37.7	84.5	1,030.0	+149	5.505	208,673.5			73	66	D.F.
	7	50.00	−0.07	38,480	39,510	37.3	38.3	88.5	1,030.0	+652	5.430	208,934.6			72	66	D.F.
	8	49.97	−0.03														
	9	49.83	−0.14														
	10	49.67	−0.16	38,680	40,249	37.5	38.8	86.5	1,029.5	+539	5.575	215,643.8			77	68	D.F.
	11	49.57	−0.10	38,500	39,972	37.3	38.8	88.0	1,029.5	− 77	5.112	196,811.8			76	68	D.F.
	12	49.47	−0.10	38,060	39,635	37.0	38.5	89.0	1,027.0	−337	5.238	199,359.5			76	68½	D.F.
	13	49.37	−0.10														

*Decrease of mean depth is owing to ledge 200 feet wide becoming submerged by slight rise, increasing water width.

Discharge observations at Atchafalaya River—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.		Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.									Air.	Water.		
			Water.	Below datum.	Mean.	Mean datum.	Maximum.										
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*	*O'clock.*	*Force.*	°	°		
Apr. 14	49.27	—0.10															
15	49.17	—0.10	37,580	39,464	36.5	38.3	86.0	1,027.0	—171	5.153	193,665.0	III½	2	63	65	D. F.	
16	49.03	—0.14															
17	48.87	—0.16	37,160	39,352	36.3	38.2	86.5	1,022.6	—112	5.615	208,638.2			66	65	D. F.	
18	48.77	—0.10	37,680	39,974	36.5	38.8	86.0	1,021.2	+622	4.886	184,116.4	III	2	76	66	D. F.	
19	48.63	—0.14	37,160	39,597	36.4	38.4	86.0	1,018.8	—377	5.718	212,472.9	X	2	76	66	D. F.	
20	48.47	—0.16	36,760	39,361	36.0	38.4	86.0	1,019.7	—236	5.154	189,454.9	VIII	1	76	66	D. F.	
21	48.33	—0.14	37,040	39,783	36.2	38.6	89.0	1,021.1	+422	5.912	218,967.4	VII	2	77	67	D. F.	
22	48.20	—0.13															
23	48.17	—0.03															
24	48.07	—0.10	36,780	39,589	35.5	38.6	85.6	1,029.5	+ 6	5.811	213,717.5	VII	1	76	67	D. F.	
25	47.97	—0.10	36,760	39,871	36.0	38.7	86.8	1,020.1	+ 82	5.447	200,247.6	IV	1	74	67	D. F.	
26	47.87	—0.10	36,320	39,533	35.6	38.3	87.0	1,018.2	—338	5.623	204,211.8	IV	5	78	68	D. F.	
27	47.73	—0.14	36,640	39,995	36.0	38.8	88.0	1,016.7	+462	5.501	201,549.1			79	69	D. F.	
28	47.57	—0.16	35,520	39,022	*43.8	37.8	88.0	810.5	—973	6.131	217,777.1	VII½	1	72	69	D. F.	*Increase in mean depth is owing to flat ledge appearing above water, narrowing width.
29	47.43	—0.14	35,740	39,356	43.9	38.2	86.0	812.5	+334	5.887	210,408.1	III½	2	75	67	D. F.	
30	47.23	—0.20															
May 1	47.07	—0.16															
2	46.93	—0.14	35,540	39,559	44.4	38.4	84.0	800.0	+203	5.559	197,573.7	IV	1	75	69	D. F.	
3	46.73	—0.20	35,860	40,040	44.0	38.8	85.0	813.9	+481	5.512	197,652.1			77	69½	D. F.	
4	46.53	—0.20															
5	46.43	—0.10	35,580	40,001	44.7	38.8	85.0	794.9	— 39	6.028	215,501.5	IX	4	79	70	D. F.	
6	46.17	—0.26	36,180	40,808	45.3	39.6	83.0	798.1	+807	5.899	213,421.9	IX	3	77	70	D. F.	
7	46.07	—0.10															
8	45.97	—0.10	35,160	39,958	43.9	38.8	86.0	800.7	—850	5.830	204,997.1	VII½	4	74	70	D. F.	
9	45.90	—0.07															
10	45.83	—0.07	35,480	40,589	45.1	39.2	84.5	785.9	+481	5.627	199,640.9	VII	2	78	72½	D. F.	
11	45.63	—0.20	35,160	40,225	44.9	39.0	84.0	782.5	—164	5.893	207,183.8	XII	2	75	71	D. F.	
12	45.40	—0.23															
13	45.13	—0.27															
14	44.93	—0.20															
15	44.73	—0.20															
16	44.53	—0.20															
17	44.33	—0.20															
18	44.13	—0.20															
19	43.93	—0.20															

	20	43.73	−0.20													
	21	43.67	−0.06													
	22	43.57	−0.10	33,580	40,258	42.8	39.0	83.0	784.3	+ 33	5.451	183,039.5	VI	3	67	68	D.F.
	23	43.47	−0.10													
	24	43.37	−0.10													
	25	43.27	−0.10													
	26	43.17	−0.10													
	27	43.10	−0.07													
	28	43.10	−0.00													
	29	43.07	−0.03													
	30	43.03	−0.04													
	31	43.13	+0.10													
June	1	43.20	+0.07													
	2	43.20	0.00													
	3	43.20	0.00													
	4	43.20	0.00													
	5	43.23	+0.03													
	6	43.30	+0.07													
	7	43.33	+0.03													
	8	43.43	+0.10													
	9	43.50	+0.07	33,320	40,058	42.2	38.8	80.0	787.8	− 205	5.901	196,636.7	V	2	78	74	M.
	10	43.53	+0.03													
	11	43.60	+0.07													
	12	43.60	0.00													
	13	43.60	0.00	33,440	40,094	42.1	38.9	82.0	793.5	+ 41	5.529	184,820.9	VII	1	86	75	M.
	14	43.60	0.00													
	15	43.63	+0.03													
	16	43.70	+0.07													
	17	43.70	+0.00													
	18	43.70	−0.00													
	19	43.67	−0.03													
	20	43.60	−0.07													
	21	43.60	0.00													
	22	43.60	0.00	33,060	39,714	41.7	38.5	82.8	792.8	− 330	5.405	178,675.9	VI	1	88	80	M.
	23	43.60	0.00													
	24	43.57	−0.03													
	25	43.50	−0.07													
	26	43.47	−0.03													
	27	43.40	−0.07													
	28	43.37	−0.03													
	29	43.30	−0.07	33,380	40,271	42.1	39.0	80.0	791.7	+ 557	5.505	183,769.2	XI	2	95	84	M.
	30	43.27	−0.03													
July	1	43.17	−0.10													
	2	43.07	−0.10													
	3	42.97	−0.10													
	4	42.87	−0.10													
	5	42.77	−0.10													
	6	42.70	−0.07	32,460	39,825	42.2	38.7	80.2	788.8	− 446	5.602	181,851.2	V	1	89	84	M.
	7	42.68	−0.02													
	8	42.57	−0.11													
	9	42.47	−0.10													
	10	42.40	−0.07													

Discharge observations at Atchafalaya River—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.		Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.									Air.	Water.		
			Water.	Below datum.	Mean.	Mean datum.	Maximum.										
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*	*O'clock.*	*Force.*	°	°		
July 11	42.37	−0.03	32,580	40,205	42.1	39.0	82.0	789.8	+ 330	5.201	169,434.6	XI½	3	92	83	M.	
12	42.27	−0.10															
13	42.17	−0.10															
14	42.07	−0.10															
15	41.97	−0.10															
16	41.87	−0.10															
17	41.80	−0.07															
18	41.77	−0.03	32,260	40,361	41.7	39.1	82.8	797.5	+ 156	5.252	169,443.9	X	2	86	81	M.	
19	41.70	−0.07															
20	41.67	−0.03															
21	41.57	−0.10															
22	41.47	−0.10															
23	41.37	−0.10															
24	41.27	−0.10															
25	41.17	−0.10															
26	41.07	−0.10															
27	40.93	−0.14	31,440	40,210	42.1	39.0	79.8	794.5	− 151	5.269	165,666.6	V	3	89	80	M.	
28	40.73	−0.20															
29	40.53	−0.20															
30	40.30	−0.23															
31	40.00	−0.30															
Aug. 1	39.70	−0.30															
2	39.35	−0.35															
3	38.90	−0.45	29,820	40,196	37.8	39.0	79.0	787.5	− 14	4.591	136,901.5	XI	1	86	81	M.	
4	38.40	−0.50															
5	37.60	−0.80															
6	36.82	−0.78															
7	36.00	−0.82															
8	35.10	−0.90															
9	34.20	−0.90															
10	33.30	−0.90															
11	32.40	−0.90	24,900	40,320	32.4	39.1	71.0	766.4	+ 124	4.193	104,417.2	XI	1	81	81	M.	
12	31.55	−0.85															
13	30.67	−0.88															
14	29.93	−0.74															
15	29.42	−0.51															

	16	28.95	—0.47	21,900	39,788	33.0	38.5	68.0	662.1	— 537	3.633	79,545.6	VI 1	100	83	M.
	17	28.50	—0.45													
	18	27.90	—0.60													
	19	27.50	—0.40													
	20	26.75	—0.75													
	21	26.10	—0.65													
	22	25.47	—0.63	19,560	39,728	30.0	38.5	65.0	650.9	— 55	3.647	71,347.3	VI 3	90	84	M.
	23	24.68	—0.79													
	24	24.00	—0.68													
	25	23.50	—0.50													
	26	22.90	—0.60													
	27	22.40	—0.50													
	28	21.90	—0.50													
	29	21.40	—0.50													
	30	21.17	—0.23	17,530	40,368	29.6	39.5	60.0	591.4	+ 640	2.755	43,296.9	XII 3	98	84	M.
	31	21.03	—0.14													
Sept.	1	20.90	—0.13													
	2	20.30	—0.60													
	3	19.40	—0.90													
	4	18.90	—0.50													
	5	18.42	—0.48													
	6	17.70	—0.72	14,640	39,509	25.2	38.3	55.6	579.2	— 859	2.813	33,870.5	IV 4	119	84(?)	M.
	7	17.18	—0.53													
	8	16.73	—0.45													
	9	16.46	—0.27													
	10	16.10	—0.36													
	11	15.80	—0.30													
	12	15.50	—0.30													
	13	15.23	—0.27													
	14	15.10	—0.13	13,080	39,396	22.7	38.2	53.0	572.5	— 113	2.870	30,392.8	VI 4	78	83	M.
	15	15.07	—0.03													
	16	14.97	—0.10													
	17	14.90	—0.07													
	18	14.80	—0.10													
	19	14.57	—0.23													
	20	14.40	—0.17													
	21	14.13	—0.27	12,500	39,419	21.9	38.2	51.6	569.3	+ 23	2.300	28,761.4	VI 4	76	......	M.
	22	13.85	—0.28													
	23	13.53	—0.32													
	24	13.40	—0.13													
	25	13.40	0.00													
	26	13.43	+0.03													
	27	13.76	+0.33	12,210	39,339	21.5	38.1	49.5	567.5	— 80	2.353	28,738.2	I 3	68	76	M.
	28	14.25	+0.49													
	29	14.60	+0.35													
	30	14.57	—0.03													
Oct.	1	14.40	—0.17													
	2	14.05	—0.35	12,400	39,368	21.6	38.1	52.0	572.3	+ 24	2.826	28,344.6	V 4	77	77	M.
	3	13.65	—0.40													
	4	13.20	—0.45													
	5	12.65	—0.55													
	6	12.27	—0.38													

Discharge observations at Atchafalaya River—Continued.

Date.	Gauge.		Dimensions of cross-section of discharge.					Width.	Scour or fill.	Mean velocity per second.	Discharge per second.	Direction and force of wind.		Temperature, Fahr.		Method.	Remarks.
	Reading.	Rise or fall in the preceding 24 hours.	Area.		Depth.												
			Water.	Below datum.	Mean.	Mean datum.	Maximum.							Air.	Water.		
1882.	*Feet.*	*Feet.*	*Sq. feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Sq. feet.*	*Feet.*	*Cubic feet.*	*O'clock.*	*Force.*	°	°		
Oct. 7	11.88	—0.39															
8	11.45	—0.43															
9	11.10	—0.35															
10	10.76	—0.34															
11	10.40	—0.36															
12	10.10	—0.30	10,440	39,632	18.7	38.4	48.0	556.6	+ 269	1.829	19,104.5	VIII	3	82	79	M.	
13	9.87	—0.23															
14	9.80	—0.07															
15	9.77	—0.03															
16	9.70	—0.07															
17	9.70	—0.00															
18	9.77	+0.07	9,950	39,327	17.5	38.1	47.1	561.5	— 305	1.998	19,882.6	VI	4	79	78	M.	
19	9.97	+0.20															
20	10.25	+0.28															
21	10.75	+0.50															
22	11.12	+0.37															
23	11.52	+0.40															
24	11.90	+0.38	10,650	38,828	18.8	37.7	49.0	565.1	— 499	2.417	25,743.5	XI	3	83	70	M.	
25	12.25	+0.35															
26	12.60	+0.35															
27	12.90	+0.30															
28	13.13	+0.23															
29	13.20	+0.07															
30	13.17	—0.03															
31	13.10	—0.07															
Nov. 1	13.07	—0.03															
2	12.93	—0.14	12,390	39,987	21.9	38.8	51.4	563.4	+1,159	2.343	29,038.0	V	3	78	70	M.	
3	12.77	—0.16															
4	12.67	—0.10															
5	12.60	—0.07															
6	12.60	0.00															
7	12.60	0.00															
8	12.60	0.00															
9	12.63	+0.03	11,770	39,536	20.9	38.4	49.5	562.1	— 451	2.282	26,858.7	VII	3	70	71	M.	
10	12.73	+0.10															
11	12.83	+0.10															
12	12.97	+0.14															

13	13.18	+0.16													
14	13.23	+0.10													
15	13.30	+0.07													
16	13.33	+0.03	11,980	39,302	21.1	33.1	51.5	563.1	− 234	2.316	27,640.4	VII 4	63	66	M.
17	13.43	+0.10													

6.—AT WINONA, MINN., JOHN EWENS, ASSISTANT IN CHARGE.

(NOTE.—Results in Report of Commission for 1882, page 127.)

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., June 1, 1883.

SIR: I have the honor to inform you that in accordance with your instructions, received in September, 1880, I proceeded to Wabasha, Minn., where I completed organization of party and made immediate preparations to carry out your instructions.

After a careful examination of the topography of the country in the vicinity of Wabasha, I found that a formidable outlet known as "Beef Slough," situated some distance back from the left bank, would make the locality a very undesirable one for the work of gauging, which first of all for its success requires the absence of outlets. Surveys and sectional soundings of the river at this point were sent to Saint Louis for examination. In a very brief time afterward orders were received for the party to remove to Winona, 47 miles below. Examinations similar to those made at Wabasha were made at Winona, and at the town of Homer, about 4 miles below. A large number of sections were sounded at both of the places mentioned, and a section for discharge measurement selected at both. The Winona section was situated about 1¼ miles below the Chicago and Northwestern Railroad bridge. This section was selected on account of the banks being higher than elsewhere in the vicinity, and owing to the absence of eddies and other disturbing elements that detract from the accuracy of discharge work. The Winona section, though the best to be found in the vicinity, presented many disadvantages which no doubt have their influence on work of this character, where refinement is so desirable. The most prominent drawback was the presence of large numbers of immense rafts which skirted the right bank for miles above and below the discharge section, extending for some distance out in the river. The effect of such obstructions on the velocity and changes of bed is so obvious that a description here of their effect is unnecessary. In consequence of the constant presence of these rafts I thought for a time that the Homer section would be preferable, but found that at high water the discharge would be partial on account of a small outlet fed by the river above this section. So, in view of all these facts, Winona was finally decided on.

On account of the absence of supplies, work with the electric plant designed by you could not be commenced until the spring of 1881. Rod-floats were employed for velocity measurements until the closing of the river, which took place on November 20, 1880. After the closing of the river preparations were begun immediately for the winter work through the ice with the water-meter. The severity of the winter in this State suggested to me the propriety of devising some plan by which the work could be continued without interruption from the cold. To meet this difficulty, a sled-house was designed and constructed. It consisted of an oblong structure, large enough for three members of the party to conduct the work in. This house was mounted on two wooden runners, which were clad with steel; a window on the front side of the structure admitted all the light required. A trap-door with a portable casing was made in the floor of the house for lowering and raising the meter. The interior furnishings consisted of a desk for recording and holding the register, a stove, thermometer, and two pulley-galleries for lowering and raising the meter and integrating. The plan of working was as follows: The stations having been previously located, a square hole was cut in the ice at each station, the center of the hole being the original location of the station-hub. A path, the center of which was the section line, the width conforming to the gauge of the runners of the sled, was then cut across the river. With these arrangements to perform the work, it was simply necessary to draw the house over the opening, raise the trap-door, and insert the trap-casing and lower the meter for the observations. The trap-casing proved to be an excellent feature of the house. It excluded the air completely, and formed a wooden casing around the opening in the ice. To illustrate how admirably the house plan worked, it will suffice for me to state that the party continued the work successfully on many days when the wind blew a perfect gale, and the thermometer indicated a temperature of 45° below zero. On these days the temperature within the house was about 80° above.

Though the work through the ice was conducted with all the care and refinement possible, the continued presence of slush ice beneath the surface no doubt detracted greatly from the accuracy of the work. Were it not for this fact, the work would have been as fine as ever has been done elsewhere, as the manner of working and apparatus used could hardly be improved on. This work was continued until the breaking up of the ice, which occurred on the morning of April 4, 1881. Though the river became free from ice on the night of April 7, the party had made arrangements during the winter so completely that they were enabled to begin discharge work with the electric plant and rod-floats on the morning of April 8, six hours after the river's becoming free from ice. The system of wire anchorage used, and the general plan of plant and method of working, have been described so fully by you in the progress report of the Commission for 1881, that a description here is unnecessary. The open-river work was continued successfully until October 23, 1881, orders having been received to leave Winona with the party on October 25, 1881. In connection with the regular discharge work, the following work was done: slope observations were taken daily, sediment and dredge specimens were taken at regular periods, and longitudinal soundings were taken as often as time would permit. The dredge-work was made of more than passing interest on account of the refinements introduced in analyzing. The system of sieves used enabled the party to do this work perfectly. The work was inspected by you in person on July 15, 1881. The computed discharges and other calculations, with maps of reach, chart showing deduced curves of discharge, velocity, and areas; also sketches showing portable sled-house and dredge; also photograph of electric plant in actual working position, are all appended to this report. The discharge data, with map of reach and curve chart, appeared in the progress report of the Commission for 1881. The necessity of beginning the work on the Lower Mississippi as soon as possible after closing the work at Winona prevented this report from accompanying the data mentioned at that time.

In conclusion, I desire to acknowledge the valuable assistance rendered by my recorder, Mr. Hiram Phillips, who performed all his duties in a manner worthy of the highest commendation I can give him.

Very respectfully, your obedient servant,

JOHN EWENS,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

7.—AT HANNIBAL, MO., HOMER P. RITTER, ASSISTANT, IN CHARGE.

(NOTE.—Results in Report of Commission for 1882, page 138.)

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., October 8, 1883.

SIR: I have the honor to submit herewith a report on the observations of the gauging party stationed at Hannibal, Mo., from October, 1880, to October, 1881.

In accordance with instructions received from you, I left Saint Louis October 9, 1880, and proceeded to the mouth of the Des Moines River to make a reconnaissance for a favorable location for obtaining the discharge of the Mississippi River below the mouth of the Des Moines River.

I arrived at Warsaw, Ill., October 11, and proceeded at once to make a reconnaissance of the river in this vicinity. On October 15 I received your communication informing me that the Commission had examined the following location, *i. e.*, 500 feet above the Hannibal bridge and connecting with the Sny Levee, and found it well adapted for a gauging station, and that it should be occupied unless a decidedly better one be discovered.

I started immediatly for Hannibal, Mo., and after examining the location indicated, I decided to locate there, finding it well adapted for gauging purposes.

A preliminary survey of the locality was then made; the discharge section established; range polls and targets erected; slope gauges established and put up; the necessary plant collected; the wire anchorage laid and the electrical float apparatus put together. Everything being ready, observations were commenced November 12, 1880, and continued until October 24, 1881, when orders were received to discontinue the observations. The party consisted of one recorder and two boatmen, with an additional boatman during high water.

Location of the section.—The section was located 500 feet above the Hannibal bridge and parallel to the same. The Mississippi River at this point is very narrow, being only 1,200 feet wide at low water; 1,500 feet at a bank-full stage, and 2,550 feet at extreme high water, 1,010 feet of the latter width being the distance from the left bank to the Sny Levee, this distance being covered only a few feet in depth during high water. On the right bank the bluffs run close to the river. The deepest water in the section was about 30 feet, at low water, distant about 400 feet from the right bank. The bottom of the river was uniform, sloping from each bank towards the deepest part. The path of the current was normal to section.

Nature of the observations.—The observations made during the season consisted of: (1) A measurement of the river's discharge, taken every available day. (2) Slope of the river surface for a distance of 2,000 feet above and 2,000 feet below the discharge-section. (3) Sediment samples of the water taken at different points in the section at various stages, to determine the amount of sediment carried in suspension.

(4) Dredging, obtaining specimens of the bottom of the river, to determine material and changes in material. (5) Tri-daily readings of the water-gauge.

Discharge.—Discharge observations with the rod-float plant were commenced November 11, and were continued November 12, 13, and 15. These observations had to be discontinued, with the exception of December 13 and 14, on account of running ice, until the river froze over, which occurred on December 29. From January 3 to March 10, inclusive, discharge observations were taken by cutting holes in the ice and using a current-meter. After the ice had broken up and ceased running (April 7), the wire anchorage was again put in, and the discharge observations with rod-float plant resumed, and continued to October 12, when observations at the station were discontinued. During the season 94 discharges were obtained, 29 of which were meter discharges. The discharge observations were reduced and computed during the season, and the results forwarded to the office at Saint Louis, Mo. Taking a discharge consisted in obtaining a cross-section of the river by means of soundings, and determining the velocity of the current at various points in the section. The soundings were taken either with a pole or a lead-line, and were 25 feet apart. A 20-pound lead was used. Velocities were taken every 100 feet by means of rod-floats or current-meter.

In determining velocities by means of rod-floats 6 rods were run to each station, and a mean taken for the observed velocity at that point. When the current-meter was used a mid-depth and an integrated velocity were taken at each station.

In reducing and computing rod discharges, the observed velocities of the rods were reduced to the mean velocity in the vertical section by Francis' formula, *i. e.*:

$$v' = v\left(1 - 0.116\left[\sqrt{\frac{D-D'}{D}} - 0.1\right]\right)$$

in which

v' = mean velocity.

v = observed velocity.

D = depth of water.

D' = immersion of rod.

The cross-section was divided into partial areas by ordinates midway between the observing stations. The mean of the result of rods run at any station was multiplied into the corresponding partial area, and the partial discharges thus obtained were added together for the total discharge. The latter quantity was divided by the total cross-section for the mean velocity of the river. The meter discharges were computed in the same manner, with the exception that a mean of the mid-depth and integrated velocity at each station was multiplied into its corresponding partial cross-section.

In taking discharges with rod floats, the following plant was used, the principal features being the wire anchorage, the electrical float apparatus, and the rod floats;

The wire anchorage consisted of a No. 9 steel wire running across the river and fastened at each shore. From this cross-wire anchor wires ran up stream every 100 feet. The anchor wires were 200 feet long, one end being fastened to the cross-wire and the other to a large stone weighing from two to three hundred pounds. When not in use, this wire system lay at the bottom of the river.

The electrical-float apparatus used was rigged in the following manner: Across the stern of a 22 foot skiff is bolted an outrigger 20 feet long and five inches wide, which is graduated to feet. From the extremities of this outrigger two wires, each 100 feet long, supported on battens, trail down stream, and to their lower ends is attached another similar strip supported on three buoys; the upper and lower strips, together with the two side wires, forming a parallelogram 20 by 100 feet. On the up-stream face of the lower outrigger is fastened a strip of sheet copper one inch wide extending the whole length of the board. In front of the above copper strip is stretched a similar copper band, supported at each end on wooden bridges.

The strip of copper which is fastened to the face of the lower outrigger is connected with an insulated wire running along one of the wires forming the parallelogram, and the copper band in front of the strip is connected with a similar insulated wire running along the other wire of the parallelogram. The two insulated wires lead into the upper skiff, where they are connected with a battery and electric bell. At the middle of the lower outrigger is attached a skiff used in catching the floats. The rods used were cylindrical in shape, 1¼ inches in diameter and from 3 to 25 feet in length. To the bottom of the rods were attached tin cans of the same diameter as the rods and from 12 to 30 inches long. These cans were filled with shot, thus enabling the rods to float in an upright position. A discharge with the float apparatus was taken in the following manner: The apparatus having been gotten ready, the shore-end of the cross-wire was raised and put over the bow of the upper skiff, where it ran over a wheel. The whole apparatus, consisting of upper skiff, side lines, and lower skiff, was then moved along the cross-wire. At every 25 feet halt was made and a sounding taken. When a velocity station was reached, which was every hundred feet, being also where one of the anchor wires ran up stream, the skiff was made fast and velocity observations taken in the following manner: A rod float was taken and weighted so as to run as near as possible, without touching, to the bottom, and allow from one to two feet projecting above the surface of the river. It was then put into the water at the head of the skiff and allowed to float, and as it passed under the upper outrigger a stop-watch was started. At the instant the float struck the lower outrigger the stop-watch was stopped and the time taken. The striking of the float was announced in the upper skiff by means of the electric bell, a circuit being formed by means of the two copper strips on the lower outrigger coming in contact when the float struck it. Both outriggers were graduated from 1 to 20 feet, and as a float passed under the upper one, the number under which it passed was noted, likewise the number on the lower outrigger where it struck was noted. If the numbers were the same, the distance traveled by the float was 100 feet, the path of the float being parallel to the sides of the rectangle. If the direction of the float was either to one side or the other, the departure was denoted by the difference of the two readings, on the upper and lower outrigger, and the distance traveled by the float computed. After a sufficient number of floats had been run at a station, the whole apparatus was moved along the wire to the next station, 100 feet distant, and the velocity observations repeated, halt having been made every 25 feet to take a sounding. The above observations were repeated at each successive station until the other side of the river was reached.

During the time that the river was frozen over, the current observations for the discharge were taken with a current-meter. Holes were cut through the ice every 25 feet, covering the whole width of the river. Through the holes soundings and velocity observations were taken. The velocity stations were 100 feet apart and in the same places as before, *i. e.*, when the float apparatus was used. The apparatus used for the current observations consisted of a modified Ellis meter, an electrical battery of two cells, an electric register, a stop-watch, a mushroom anchor, to which is attached a ¼-inch wire rope on which the meter was let up and down, and 75 feet of insulated copper wire. In taking velocity observations through holes cut in the ice, the meter was let down on a vertical wire; this vertical wire was held on the bottom of the river by means of a mushroom anchor, the upper end being fastened to a stake in the ice. The meter was let down by means of a wire around which was twisted the insulated wires, forming the circuit between the meter and the battery and register. Mid-depth velocities were taken by letting the meter down to the required depth and allowing it to run from three to five minutes, the number of revolutions as recorded by the register being put down at the end of each minute.

Integrated velocities were taken by moving the meter at a continuous uniform rate from top to bottom and back to surface, time and number of revolutions being recorded at starting, arrival at bottom, and return to surface. The meter was rated at beginning and tested several times during the period that the meter was used.

Slope-gauges.—The slope-gauges were read on 71 different days, extending from June 11, 1881, to October 12, 1881. The slope-gauges had been erected the previous November, but were continually knocked out by ice and lumber rafts. After June 11 no trouble was experienced. The gauges, 9 in number, were placed on the Illinois side of the river, 4 above and 4 below the discharge-section, the remaining one being on the discharge-section. They were set by means of a level, and were frequently tested.

The horizontal distance between each gauge was 500 feet, embracing in all 4,000 feet of the river.

The gauges used were of the vertical type, graduated to feet and tenths, and the readings estimated to hundredths. They were read as near simultaneously as possible, the entire party being distributed along the line, reading the gauges at a given signal.

Sediment.—Sediment was taken 73 times at various intervals from December 3, 1880, to October 12, 1881, the intervals depending on the turbidity of the river. During high stages the observations were taken daily, and during lower stages, when the river contained little or no sediment, once a week. In taking sediment, the section was divided into 8 equi-distant stations. At each station 6 samples of 2 ounces of water were taken by means of the slip-bottle, two samples from the surface, two from mid-depth, and two from the bottom. The samples of water were put in bottles and sent to the Saint Louis office, where they were analyzed and the amount of sediment determined.

Dredging.—From January 5, 1881, to October 14, thirty-nine consecutive sets of dredgings were taken to determine the change in the material composing the bottom of the river at the section. The section was dredged once a week. Specimens of the bottom of the river were taken from seven different points in the section at each dredging from January 5 to March 7.

From March 24 to October 14 nine different points in the section were taken, two more stations being added on the Illinois side of the river.

From January 5 to March 7, the dredgings were made through holes cut in the ice in the manner described below. From March 24 to October 14, the dredging was done from a skiff, by means of a canvas bag surrounding an iron frame, to which a rope was attached.

The stations used, with the addition of the two mentioned above, were the same as previous dredgings.

A specimen of the bottom of the river obtained by each dredging was kept, dried, and analyzed.

The specimens, 324 in number, put in tin boxes and labeled, were forwarded to Saint Louis, Mo. The specimens were analyzed in the field, and the results, in tabular form, comprising 39 sheets, forwarded. When dredging through holes in the ice the following-described dredge was found to answer the purpose. It consisted of a cylinder of sheet-iron 18 inches long and 6 inches in diameter, open at one end and closed at the other. A strip of wrought iron 1 by ¼ by 20 inches was riveted to the outside (lengthwise) of the cylinder, and allowed to project a few inches beyond the open end. To this strip was screwed a rod made of half-inch gas-pipe. The rod was composed of sections, each 7 feet long, with gas-pipe couplings for screwing together, thereby permitting the rod to be lengthened or shortened, as the depth required.

The section nearest the cylinder was bent upwards at an angle of about 130°, allowing the cylinder to be pulled along the bottom, scooping up the material. The dredge was let into the water-cylinder—end down stream. In pulling it up to the surface, the cylinder assumed a perpendicular position, thereby enabling the material from the bottom to be brought up without undergoing any change by having the smaller particles washed out. The dredge was found to work without fail every time and at all depths in the section.

Very respectfully, your obedient servant,

HOMER P. RITTER,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

8.—AT GRAFTON, ILL., J. H. DAVIS, ASSISTANT IN CHARGE.

(NOTE.—Results in Report of Commission for 1882, page 142.)

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., July 13, 1883.

SIR: I have the honor to submit the following report, on the observations at Grafton, Illinois, made from October 15, 1880, to October 25, 1881.

The scene of operations was reached by the assistant about the middle of October. There was neither material nor assistance at hand, so that little more than locating could be done during the first week. Upon the arrival of two boatmen, a reconnaissance of the most favorable portion of the river was made, for the purpose of locating a gauging section. Upon the arrival of C. L. Harrison, recorder, the party was complete, consisting of assistant, recorder, and two boatmen. There was a good deal of preliminary work to be done in putting up gauges, constructing plant, putting in anchorage, laying off ranges and putting up signals. Owing to the fact that no instruments were furnished, and the material and tools were delayed, much time was lost unnecessarily in this work. Most of it had to be done with borrowed utensils. Finally, on the 13th of November, the preparations had advanced sufficiently to measure a discharge by the method of plant set forth in the instructions.

The serial work consisted of—

1st. Discharge observations.
2d. Sediment observations.
3d. Dredging observations.
4th. Slope observations.
5th. Determining vertical velocity curves.

STATEMENT.

The discharge observations were made daily, when practicable, Sunday excepted. During the year 191 discharges were measured. They were distributed, by method, as follows:

By double floats, located with transit	80
By rod floats, located with transit	25
By double floats, with plant	6
By rod floats, with plant	39
By double floats, not located	26
By current meter	15
Total	191

The sediment observations were very irregular in the early part of the season. Soon after the work began, the boats stopped running on account of ice, and did not resume until March. During this period there was no way of forwarding specimens, and so none were taken. After the boats commenced running again, sediment was taken daily, with few exceptions, until August, when it was taken weekly. Several omissions occurred on account of the shipping-boxes not being promptly returned. During the year 98 sets of samples were taken and forwarded to the office.

The dredgings were taken monthly, after and including March. The instructions to take them were not received till late in December, and it was impossible to obtain samples during the months of January and February. Ten sets of specimens were taken and forwarded to the office.

The slope observations were made daily when more important work did not occupy the full time. A large number of the observations were rendered worthless by the gauges being destroyed before a level was obtained with which to connect them. About 125 sets of serviceable observations were made.

The vertical velocity observations were made with the meter during the ice period. During the month of January 119 curves were determined at 13 different stations across the river.

Discharge observations.—As already stated, the first discharge was taken on November 13; another was taken on the 15th, both being by the plant method. On the 16th of November the ice commenced to flow in large quantities, and from that date till March 7 the river was not clear of it.

After a few days of running ice the river blocked, but did not freeze over. For several weeks there were immense fields of ice that covered more than half the river, but were not solid enough to work upon. This continued through December, during which time it was impossible to measure discharges. As soon as the river became solid in January, the meter was brought into immediate use. The ice remained solid till the 2d of February, and the meter was employed up to that time; there were a few omissions owing to repairs needed on the instrument. Although the ice became too weak for further work upon it early in February, it did not break away till the last of the month. Meanwhile no discharges could be measured. As soon as the ice commenced to flow, discharges were taken by timing ice chunks, a few floats being run where a skiff could be handled. The distances were all estimated by guess. After the ice stopped running, the use of double floats was continued until a new anchorage could be put in and arrangements made for using the plant; during March and April, twenty-six sets of observations were made in this way. On the 5th of April the anchorage was completed and the original method by plant resumed. By this time the river was becoming very high. After five sets of observations were made with the plant the anchorage was swept away by the swelling volume of water. Repeated efforts were made to replace it. Several wires were stretched across the river, but were broken before being used; some of the breaks were occasioned by logs catching on them near shore. Finally, upon witnessing the wire break in midstream from the force of the current alone, all efforts to keep it in were abandoned. Upon an urgent request a transit was furnished the party, and on April 16 the first set of observations was made with double floats located from shore. This method was kept up till the middle of July, ninety-one discharges having been taken in this way.

About the middle of July, free rods were substituted for double floats, the river then being low enough to handle them conveniently. This was not practicable in high water, with a skiff party of only two boatmen, who had to manage the skiff, handle the floats, take and record the soundings. Free rods were used and located with transit until August, 25 discharges being taken. On the 19th of August the plant method was resumed, the river having become sufficiently low to make it practicable. Rods were now used exclusively. This method was kept up till the 4th of October, thirty-eight discharges having been taken. By the 1st of October the river had again risen bank full, and as a result the anchorage was again carried away. Several unsuccessful attempts were made to put in a new one. At this time the party consisted of an assistant and two boatmen, the recorder having been assigned to other duties. After spending nearly two weeks in trying to put in a new anchorage, it was considered useless to make any further effort until the river should fall.

The party was now too small to resume any of the other methods employed, so it was decided to occupy the time in running some additional levels to check the slope gauges, and to connect the daily gauge with a precise level bench.

On the 15th of October, instructions were received to close the work on the 25th of October, and report at the office at the earliest convenience.

Description of methods employed in discharge measurements.

1st. *By plant.*—The method described in your report contained in the progress report of the Commission for 1882, was not materially departed from. In case of an up-stream or cross-stream wind, it was found necessary to drop a small anchor at the stern of the lower skiff, in order to keep the side wires stretched. The immersion of rod required at each station was determined by longitudinal soundings made about three times a week.

2d. *By double floats.*—They were located instrumentally on two ranges 100 feet apart. The angles were taken with a transit stationed at the end of a 940-foot base. Telegraphic signals were given at the time of the floats crossing the ranges. The observer determined when the float reached the range, by sighting across a vertical wire kept in line with a signal on the opposite side of the river. A pair of binoculars was used to enable him to see the float distinctly; the wire and signal could also be seen at the same time. The observer that gave signals also timed the float with a stop-watch. Soundings were taken upon each of the ranges by one of the boatmen, who also acted as recorder. The boatmen also manipulated the floats. The skiff was kept directly behind the float, and the soundings were taken in its path.

In the observations made without the use of a transit, the distance of the float from shore was estimated by guess by an observer in the skiff. Only four or five points in the section were estimated in this way, the others being interpolated. A surprising degree of accuracy was attained in this way, as shown by the regular increase of the water area for that period, from the first of March to the middle of April. The velocities, depending to considerable extent upon the corresponding stage of the Missouri River, do not increase so regularly.

3d. *By the current meter.*—This method was employed when the river was frozen over. Twelve stations were located at equal intervals across the river. At each station a hole was cut in the ice sufficiently large for lowering the meter and the accompanying apparatus. The meter was clamped to a foot-piece that worked on a standing wire attached to a weight that rested on the bottom. The meter was lowered on the wire by means of a cord, graduated so that any desired depth could be reached. The greatest river depth at that time was about 14 feet, so that the meter could be lowered to the bottom with perfect ease. At each of the stations the work consisted of velocities at mid-depth and by integration, and also at all depths, when it was desired to take a vertical curve. At mid-depth the meter was run several minutes, being timed for each minute separately. The integration was taken from the surface to the bottom and return. In this the time and revolutions of the meter were taken at the bottom without stopping the motion of the meter. A uniform movement was maintained during the integrations by letting out and taking in the cord regularly by hand. It was impossible to use a reel for this purpose on account of the cord becoming frozen soon after reaching the surface. To prevent the meter from becoming covered with ice when changing stations, it was immersed in a tub of water. The adjustments had to be made under water.

Rating.—The meter was rated in the following manner: A longitudinal cut a foot wide and about 150 feet in length was made in the ice of a pond containing water 1½ to 2 feet in depth. The meter was clamped to an iron rod, secured in a vertical position at the front end of a sled that was made to run astride the longitudinal opening. Two flanges were placed inside of the runners and made to move along the opening to prevent the sled from turning either to the right or left. A uniform movement of the sled was obtained by pushing it, the men taking even steps meanwhile. The meter being clamped on the rod was immersed to a depth of about 1 foot. That was considered sufficient, as there was little disturbance of the surface water during the operation. The meter was timed over a distance of 100 or 125 feet. A rating consisted of from 20 to 30 observations, the rates varying from ½ to 8 feet per second. During the use of the meter there were 5 ratings made.

Sediment observations.—Samples were taken at 8 points on the gauging section. They were taken at the surface, at mid-depth, and near the bottom. These were combined vertically and horizontally. The vertical combination for any station contained two ounces at each depth placed in one bottle. Eight bottles were thus required for one day's samples. In the horizontal combination, two ounces of each of the surface samples were placed in one bottle, two ounces of each of the mid-depth samples were placed in a second bottle, and two ounces of each of the bottom samples were placed in a third bottle. Three bottles were thus required for a day's samples. The bottles containing the samples were sealed, properly labeled, and forwarded to the office at regular intervals. The analysis was made under your supervision.

Dredging observations.—The samples were taken with a bucket designed and constructed during the progress of the work. It was of the following construction: Two of its faces were trapezoids, the remaining four being rectangles. The bottom was considerably enlarged in one direction. The height was about one and a half times any other dimension. The bucket had a bail and a hinged lid, so connected that the lid was closed when the bucket hung vertically. Upon inclining the bucket the lid was thrown open. The bucket was so balanced that when empty it hung at an angle, the lid being open. Upon filling it with any heavy material a vertical position was assumed, the lid then being closed. There was also a strip of iron riveted across the bottom, that caused the bucket to fall forward upon reaching the bottom. In this position it was easily filled. Upon lifting it up a vertical position was assumed, the lid closed, and the sample preserved. The bucket was made watertight so as to hold the finest material. The bucket was lowered while drifting, and filled by rowing a few strokes down-stream. The boat was then held up somewhat by backing, until the bucket was brought to the surface. The apparatus worked with entire satisfaction. The samples were taken at six stations, distributed at equal intervals across the river; from 1 to 2 pints were preserved. They were placed in tin cans, which were carefully closed, packed in a large box and forwarded to the office. No analysis was made of them in the field for want of a microscope.

Slope observations.—The method of obtaining slope was by making simultaneous readings on a series of gauges, erected at regular intervals along shore. For this purpose, 9 gauges were erected 500 feet apart, extending for a distance of 2,000 feet above and below the gauging section. The gauges were graduated to half tenths of a foot, and by means of a vernier could be read to thousandths, approximately. In taking the readings, a box was placed around the gauge, that extended about 2 feet below the surface. The water was admitted through a small aperture in the bottom of the box. In this way, surface waves were kept away from the gauge while being read. In reading the gauges, the force was divided into two parties, each one having a skiff. One party went to the upper gauge, A, and the other to the middle gauge, E. Upon a signal passing, both parties commenced, and read down-stream as rapidly as possible. Gauge E was read a second time by the upper party upon reaching it. Having been read at starting by the lower party, any change that had occurred could be detected, and corrections made accordingly on all the readings. Unfortunately, a good deal of work in this connection was lost, on account of having no level till late in the summer. All the gauges that had been read previous to March 17 were destroyed by ice, no connection having been made. These were on the Illinois shore. A new set was erected on the Missouri shore about March 17. A great number of gauges had to be put in at each station as the river went down. When a new one was put up, it was checked by the one previously in use. In this way a continuous set of gauge readings was obtained at most of the stations, until a level was received about July 15, and connection made. However, many of the gauge rods were slightly disturbed, at times, by caving banks and floating logs. For this reason, the slope for short reaches cannot be implicitly relied on in all cases. The slope for the whole reach will be found more reliable, as the errors are not large enough to materially affect the total fall.

Vertical velocity curves.—These were taken with the meter, during the ice season, and in connection with the discharge work. The velocities were obtained by taking minute observations, at points one foot apart, from the surface to the bottom. The highest point was taken just below the under surface of the ice. The lowest point was about one foot from the bottom. The meter was lowered as in the discharge work, the immersion being obtained from the graduation of the lowering cord. Curves were taken at each of the twelve stations used in measuring discharges. Three curves were taken at a station located in deeper water than any found on the discharge section.

REMARKS.

After the observations were fairly begun in January, the greater part of the time of both assistant and recorder was required in the field. All the spare time was occupied in computing velocities and discharges. With the exception of about two weeks, when the assistant was away, the velocities were computed in the field. About 70 discharges were also computed. The remainder of the computations, the tabulation and plotting, were done in the office under your immediate supervision. During the latter part of November, and nearly the whole of December, no field work could be done except to attend to the slope gauges. The remainder of the time of the assistant and recorder was occupied in computing some tables for reducing velocities. In this way much time was saved in the computations made during the working season. Mr. C. L. Harrison, recorder, was an able and reliable assistant. During my leave of absence, extending from the 12th to the 29th of September, he was in full charge of the observations, and executed the work with entire satisfaction. The assistant labored under great disadvantages, owing to the location of the station. It was frequently impracticable to carry out the instructions. In this case, the method was pursued that seemed, in the judgment of the assistant, best adapted to the circumstances.

Respectfully submitted.

J. H. DAVIS,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

9.—PROBABLE DISCHARGES OF THE MISSISSIPPI RIVER AT VARIOUS POINTS, DURING THE YEARS 1881 AND 1882.

Table showing daily discharge of the Mississippi River at Prescott, Wis., January 1, 1882, *to January* 1, 1883.

[Computed from the gauge readings by a formula deduced from discharge observations at the same point in 1881.]

NOTE.—As the Prescott gauge was not read in 1882, the gauge readings at Hastings, Minn. (3 miles above Prescott), were taken, after corrections for slope and changes of slope.

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.
1882.			1882.			1882.		
Jan. 1	180.8	18	Feb. 15	180.4	17	Apr. 1	184.2	33
2	180.9	18	16	180.4	17	2	184.7	35
3	181.0	19	17	180.4	17	3	185.2	37
4	181.2	19	18	180.5	17	4	185.7	39
5	181.4	20	19	180.5	17	5	186.2	42
6	181.5	20	20	180.5	17	6	186.7	46
7	181.6	21	21	180.6	17	7	187.2	50
8	181.7	21	22	180.6	17	8	187.7	54
9	181.9	22	23	180.7	18	9	188 2	59
10	181.8	22	24	180.7	18	10	188.7	63
11	181.8	22	25	180.6	17	11	189.2	68
12	181.7	21	26	180.5	17	12	189.7	73
13	181.6	21	27	180.4	17	13	190.3	80
14	181.7	21	28	180.5	17	14	190 2	79
15	181.7	21	Mar. 1	180.5	17	15	190.1	78
16	181.7	21	2	180.9	18	16	189.9	75
17	181.7	21	3	181.3	20	17	189.8	74
18	181.6	21	4	181.8	22	18	189.7	73
19	181.6	21	5	182.2	24	19	189.6	72
20	181.6	21	6	182.7	25	20	189.6	72
21	181.6	21	7	183.2	28	21	189.5	71
22	181.6	21	8	183.2	28	22	189.4	70
23	181.5	20	9	183.2	28	23	189.3	69
24	181.4	20	10	183.1	27	24	189.2	68
25	181.3	20	11	183.0	27	25	189.1	67
26	181.4	20	12	182.8	26	26	189.1	67
27	181.5	20	13	182.7	25	27	189.0	66
28	181.4	20	14	182.6	25	28	189.0	66
29	181.3	20	15	182.4	24	29	189.0	66
30	181.3	20	16	182.2	24	30	188.9	65
31	181.2	19	17	182.1	23	May 1	188.6	63
Feb. 1	181.2	19	18	182.1	23	2	188.5	62
2	181.2	19	19	182.1	23	3	188.3	60
3	181.1	19	20	182.1	23	4	188.2	59
4	181.0	19	21	182.2	24	5	188.0	57
5	180.9	18	22	182 2	24	6	187.8	55
6	180.9	18	23	182.1	23	7	187.6	53
7	180.8	18	24	182.2	24	8	187.4	52
8	180.8	18	25	182.3	24	9	187.2	50
9	180.7	18	26	182.3	24	10	187.4	52
10	180.7	18	27	182.4	24	11	187.6	53
11	180.6	17	28	182.7	25	12	188.1	56
12	180.6	17	29	183.1	27	13	188.6	63
13	180.5	17	30	183.4	28	14	189.2	68
14	180.5	17	31	183.8	30	15	189.8	74

Table showing daily discharge of the Mississippi River at

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.
1882.			1882.		
May 16	189.7	73	Aug. 1	183.1	27
17	189.6	72	2	183.0	27
18	189.4	70	3	182.9	26
19	189.2	68	4	182.9	26
20	189.0	66	5	182.9	26
21	188.7	63	6	182.7	25
22	188.5	62	7	182.5	25
23	188.3	60	8	182.2	24
24	188.3	60	9	182.0	23
25	188.3	60	10	181.8	22
26	188.3	60	11	181.6	21
27	188.3	60	12	181.5	20
28	188.2	59	13	181.4	20
29	188.0	57	14	181.3	20
30	187.9	56	15	181.2	19
31	187.7	54	16	181.2	19
June 1	187.7	54	17	181.1	19
2	187.6	53	18	181.0	19
3	187.4	52	19	180.9	18
4	187.3	51	20	180.8	18
5	187.2	50	21	180.7	18
6	187.1	50	22	181.0	19
7	187.0	49	23	181.0	19
8	186.7	46	24	181.0	19
9	186.4	43	25	180.9	18
10	186.2	42	26	181.2	19
11	186.0	41	27	181.5	20
12	185.7	39	28	181.6	21
13	185.4	38	29	181.7	21
14	185.2	37	30	181.6	21
15	185.0	36	31	181.5	20
16	184.7	35	Sept. 1	181.1	19
17	184.5	34	2	180.8	18
18	184.3	33	3	180.6	17
19	184.0	32	4	180.2	16
20	184.2	33	5	179.8	14
21	184.4	34	6	179.6	14
22	185.7	39	7	179.4	13
23	185.0	36	8	179.2	12
24	185.5	38	9	179.0	12
25	186.0	41	10	178.8	11
26	186.6	45	11	178.6	10
27	187.1	50	12	178.5	10
28	187.4	52	13	178.3	9
29	187.7	54	14	178.2	9
30	187.7	54	15	178.1	9
July 1	187.7	54	16	178.0	9
2	187.7	54	17	177.9	9
3	187.6	53	18	177.8	8
4	187.6	53	19	177.7	8
5	187.5	53	20	177.6	8
6	187.3	51	21	177.5	8
7	187.0	49	22	177.4	7
8	186.9	48	23	177.3	7
9	187.0	49	24	177.3	7
10	187.0	49	25	177.3	7
11	187.1	50	26	177.2	7
12	187.2	50	27	177.2	7
13	187.3	51	28	177.2	7
14	186.9	48	29	177.2	7
15	186.6	45	30	177.2	7
16	186.3	43	Oct. 1	177.2	7
17	186.1	41	2	177.2	7
18	185.7	39	3	177.3	7
19	185.4	38	4	177.3	7
20	185.1	37	5	177.4	7
21	184.8	35	6	177.4	7
22	184.5	34	7	177.5	8
23	184.2	33	8	177.7	8
24	183.9	31	9	177.9	9
25	183.7	30	10	178.2	9
26	183.6	29	11	178.5	10
27	183.5	29	12	178.7	10
28	183.5	29	13	178.9	11
29	183.4	28	14	179.1	12
30	183.3	28	15	179.3	13
31	183.3	28	16	179.4	13

Table showing daily discharge of the Mississippi River at Winona, Minn., January 1, 1882, *to January* 1, 1883.

[Computed from the gauge readings by a formula deduced from discharge observations at the same point in 1881.]

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.
1882.			1882.			1882.		
Jan. 1	437.3	30	Mar. 16	438.2	36	May 29	442.7	75
2	438.6	39	17	438.1	35	30	442.6	74
3	439.8	48	18	438.0	35	31	442.6	74
4	440.1	50	19	438.1	35	June 1	442.5	73
5	440.1	50	20	438.1	35	2	442.4	72
6	440.2	51	21	438.2	36	3	442.3	71
7	440.5	54	22	438.3	37	4	442.3	71
8	440.8	56	23	438.3	37	5	442.3	71
9	440.8	56	24	438.2	36	6	442.1	69
10	440.8	56	25	438.1	35	7	442.0	68
11	440.9	57	26	438.1	35	8	442.0	68
12	440.8	56	27	438.2	36	9	441.9	67
13	440.5	54	28	438.5	38	10	441.8	66
14	440.4	53	29	438.7	39	11	441.7	65
15	439.8	48	30	439.3	44	12	441.5	63
16	439.4	45	31	439.8	48	13	441.3	61
17	438.3	37	Apr. 1	440.1	50	14	441.2	60
18	438.1	35	2	440.2	51	15	441.0	58
19	438.6	39	3	440.3	52	16	440.8	56
20	439.3	44	4	440.4	53	17	440.5	54
21	439.4	45	5	440.8	56	18	440.3	52
22	439.7	47	6	441.4	62	19	440.1	50
23	439.5	46	7	441.6	64	20	439.9	49
24	439.3	44	8	442.7	75	21	439.6	46
25	439.2	44	9	443.6	84	22	439.6	46
26	439.1	43	10	444.2	90	23	439.8	48
27	438.9	41	11	444.7	96	24	440.2	51
28	439.0	42	12	445.1	100	25	440.3	52
29	438.7	39	13	445.4	104	26	440.4	53
30	437.6	32	14	445.4	104	27	441.0	58
31	438.2	36	15	445.2	101	28	441.7	65
Feb. 1	438.6	39	16	445.0	99	29	442.1	69
2	438.8	40	17	444.8	97	30	442.3	71
3	438.7	39	18	444.6	95	July 1	442.3	71
4	438.7	39	19	444.3	91	2	442.3	71
5	438.6	39	20	444.1	89	3	442.3	71
6	438.6	39	21	444.0	88	4	442.4	72
7	438.6	39	22	443.8	86	5	442.3	71
8	438.6	39	23	443.8	86	6	442.1	69
9	438.5	38	24	443.8	86	7	442.1	69
10	438.5	38	25	443.8	86	8	442.1	69
11	438.4	37	26	443.6	84	9	442.1	69
12	438.6	39	27	443.6	84	10	441.9	67
13	438.7	39	28	443.6	84	11	441.8	66
14	438.6	39	29	443.6	84	12	441.8	66
15	438.6	39	30	443.4	82	13	441.7	65
16	438.7	39	May 1	443.4	82	14	441.7	65
17	438.8	40	2	443.2	80	15	441.7	65
18	439.1	43	3	443.1	79	16	441.7	65
19	439.7	47	4	443.0	78	17	441.7	65
20	440.2	51	5	443.0	78	18	441.7	65
21	439.4	45	6	442.8	76	19	441.5	63
22	439.7	47	7	442.6	74	20	441.1	59
23	440.1	50	8	442.4	72	21	440.8	56
24	440.3	52	9	442.3	71	22	440.6	55
25	440.4	53	10	442.3	71	23	440.2	51
26	440.2	51	11	442.3	71	24	440.0	50
27	440.7	56	12	442.3	71	25	439.8	48
28	440.7	56	13	442.4	72	26	439.6	46
Mar. 1	439.8	48	14	442.9	77	27	439.6	46
2	439.0	42	15	443.8	86	28	439.3	44
3	438.6	39	16	444.6	95	29	439.1	43
4	438.6	39	17	444.8	97	30	439.0	42
5	438.6	39	18	444.7	96	31	439.0	42
6	438.8	40	19	444.6	95	Aug. 1	438.9	41
7	438.9	41	20	444.4	92	2	438.9	41
8	439.0	42	21	444.2	90	3	438.9	41
9	439.0	42	22	444.0	88	4	438.9	41
10	438.8	40	23	444.4	92	5	438.8	40
11	438.7	39	24	443.5	83	6	438.9	41
12	438.6	39	25	443.3	81	7	439.0	42
13	438.5	38	26	443.2	80	8	439.0	42
14	438.4	37	27	443.3	81	9	438.8	40
15	438.3	37	28	442.8	76	10	438.6	39

Table showing daily discharge of the Mississippi River at Winona, Minn.—Contin

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Di i cu per
1882.			1882.			1882.		
Aug. 11	438.3	37	Sept. 28	436.3	24	Nov. 15	437.9	
12	438.2	36	29	436.3	24	16	437.9	
13	438.0	35	30	436.5	25	17	438.2	
14	437.8	33	Oct. 1	436.5	25	18	438.3	
15	437.8	33	2	436.3	24	19	438.4	
16	437.7	33	3	436.2	23	20	438.1	
17	437.6	32	4	436.1	23	21	438.1	
18	437.5	31	5	436.1	23	22	438.0	
19	437.2	29	6	436.1	23	23	437.9	
20	437.3	30	7	436.2	23	24	437.8	
21	437.3	30	8	436.5	25	25	437.7	
22	437.3	30	9	436.7	26	26	437.4	
23	437.3	30	10	436.8	26	27	437.3	
24	437.3	30	11	436.9	27	28	437.2	
25	437.2	29	12	437.3	30	29	436.9	
26	437.6	32	13	437.8	33	30	436.8	
27	438.1	35	14	438.1	35	Dec. 1	436.7	
28	438.3	37	15	438.3	37	2	436.4	
29	438.6	39	16	438.7	39	3	436.3	
30	438.8	40	17	438.9	41	4	436.2	
31	439.0	42	18	439.0	42	5	436.2	
Sept. 1	439.0	42	19	439.1	43	6	436.0	
2	439.1	43	20	439.1	43	7	437.7	
3	439.1	43	21	439.1	43	8	437.7	
4	438.9	41	22	439.2	44	9	437.8	
5	438.8	40	23	439.2	44	10	437.9	
6	438.5	38	24	439.0	42	11	437.9	
7	438.2	36	25	438.7	39	12	438.2	
8	438.1	35	26	438.5	38	13	438.3	
9	437.9	34	27	438.3	37	14	438.6	
10	437.8	33	28	438.2	36	15	438.7	
11	437.7	33	29	438.2	36	16	438.6	
12	437.6	32	30	438.1	35	17	438.6	
13	437.3	30	31	437.9	34	18	438.8	
14	437.3	30	Nov. 1	437.9	34	19	438.9	
15	437.3	30	2	437.9	34	20	439.1	
16	437.3	30	3	437.8	33	21	439.3	
17	437.2	29	4	437.8	33	22	439.4	
18	437.1	28	5	437.7	33	23	439.5	
19	436.9	27	6	437.7	33	24	439.5	
20	436.8	26	7	437.7	33	25	439.3	
21	436.8	26	8	437.7	33	26	439.3	
22	436.8	26	9	437.7	33	27	439.2	
23	436.6	25	10	437.7	33	28	439.0	
24	436.5	25	11	437.7	33	29	438.9	
25	436.4	24	12	437.8	33	30	438.8	
26	436.4	24	13	437.9	34	31	438.6	
27	436.3	24	14	437.9	34			

Table showing *daily discharge of the Mississippi River at Hannibal, Mo., January*
to January 1, 1883.

[Computed from the gauge readings by a formula deduced from discharge observations at t
point in 1881.]

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Di i cu per
1882.			1882.			1882.		
Jan. 1	78.5	95	Jan. 13	75.5	56	Jan. 25	75.1	
2	77.8	85	14	75.2	53	26	74.4	
3	77.3	78	15	75.0	51	27	74.6	
4	77.2	77	16	74.7	48	28	75.1	
5	77.0	74	17	74.3	44	29	74.4	
6	75.8	59	18	74.3	44	30	75.1	
7	75.2	53	19	73.5	36	31	75.6	
8	75.2	53	20	73.5	36	Feb. 1	75.4	
9	75.0	51	21	74.1	42	2	75.2	
10	74.8	49	22	74.3	44	3	75.3	
11	74.8	49	23	74.7	48	4	75.7	
12	75.2	53	24	74.8	49	5	75.8	

Table showing daily discharge of the Mississippi River at Hannibal, Mo., &c.—Continued.

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.
1882.			1882.			1882.		
Feb. 6	75.9	60	Apr. 24	86.5	247	July 10	84.6	205
7	76.1	63	25	87.2	263	11	84.2	196
8	76.3	65	26	87.9	280	12	84.0	192
9	76.2	64	27	88.2	287	13	83.7	186
10	75.9	60	28	88.2	287	14	83.4	180
11	75.8	59	29	87.8	278	15	83.1	174
12	75.8	59	30	87.5	271	16	82.9	170
13	76.0	62	May 1	87.1	261	17	82.6	164
14	76.0	62	2	86.7	251	18	82.2	156
15	75.8	59	3	86.2	240	19	82.0	152
16	75.9	60	4	86.0	236	20	81.6	144
17	76.1	63	5	85.7	229	21	81.2	138
18	76.2	64	6	85.7	229	22	80.7	130
19	76.3	65	7	86.4	244	23	80.4	125
20	76.4	66	8	87.2	263	24	80.1	120
21	77.0	74	9	87.6	273	25	79.9	117
22	76.7	70	10	87.6	273	26	79.6	111
23	76.1	63	11	87.6	273	27	79.4	108
24	75.8	59	12	87.3	265	28	79.2	104
25	75.6	57	13	87.0	258	29	79.1	103
26	75.5	56	14	87.0	258	30	79.0	102
27	75.3	54	15	86.8	253	31	79.1	103
28	75.3	54	16	86.5	247	Aug. 1	79.2	104
Mar. 1	75.7	58	17	86.0	236	2	79.2	104
2	76.2	64	18	85.5	225	3	79.0	102
3	76.7	70	19	84.9	211	4	78.8	99
4	77.2	77	20	84.3	198	5	78.9	101
5	77.7	84	21	83.7	186	6	79.2	104
6	78.1	89	22	83.1	174	7	78.9	101
7	78.4	94	23	82.5	162	8	79.0	102
8	78.7	98	24	82.1	154	9	78.6	96
9	78.9	101	25	82.2	156	10	78.5	95
10	79.9	117	26	82.3	158	11	78.2	91
11	79.9	117	27	83.2	176	12	77.9	87
12	79.8	115	28	84.7	207	13	77.6	82
13	79.7	113	29	85.7	229	14	77.3	78
14	79.5	110	30	86.3	242	15	77.2	77
15	79.3	106	31	86.5	247	16	77.2	77
16	79.1	103	June 1	86.4	244	17	76.9	72
17	79.3	106	2	86.5	247	18	76.7	70
18	79.4	108	3	86.6	249	19	76.6	69
19	80.0	119	4	86.9	255	20	76.5	68
20	80.3	124	5	87.2	263	21	76.4	66
21	80.4	125	6	87.2	263	22	76.4	66
22	80.3	124	7	86.7	251	23	76.3	65
23	80.4	125	8	85.8	231	24	76.2	64
24	80.4	125	9	85.0	214	25	76.1	63
25	80.4	125	10	84.2	196	26	76.0	62
26	80.4	125	11	84.0	192	27	75.8	59
27	80.2	122	12	84.7	207	28	75.6	57
28	80.2	122	13	85.3	220	29	75.6	57
29	80.1	120	14	85.9	233	30	75.6	57
30	80.3	124	15	85.8	231	31	75.6	57
31	80.7	130	16	85.6	227	Sept. 1	75.5	56
Apr. 1	81.0	134	17	85.2	218	2	75.5	56
2	81.1	136	18	84.5	203	3	75.5	56
3	81.2	138	19	83.7	186	4	75.6	57
4	81.3	139	20	83.2	176	5	75.7	58
5	81.3	139	21	82.7	166	6	75.8	59
6	81.3	139	22	82.9	170	7	76.1	63
7	81.3	139	23	82.4	160	8	76.3	65
8	81.6	144	24	82.4	160	9	76.5	68
9	82.0	152	25	82.7	166	10	76.4	66
10	82.6	164	26	83.0	172	11	76.3	65
11	82.9	170	27	84.2	196	12	76.2	64
12	83.0	172	28	85.2	218	13	76.2	64
13	83.2	176	29	86.5	247	14	76.0	62
14	83.3	178	30	87.6	273	15	75.9	60
15	83.4	180	July 1	88.1	285	16	75.7	58
16	83.4	180	2	88.4	292	17	75.6	57
17	83.5	182	3	88.2	287	18	75.5	56
18	83.5	182	4	87.9	280	19	75.5	56
19	83.6	184	5	87.4	268	20	75.3	54
20	83.9	190	6	86.9	255	21	75.2	53
21	84.3	198	7	86.2	240	22	75.0	51
22	84.8	209	8	85.2	218	23	74.8	49
23	85.6	227	9	84.9	211	24	74.7	48

Table showing daily discharge of the Mississippi River at Hannibal, Mo., &c.—Continued.

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.
1882.			1882.			1882.		
Sept. 25	74.6	47	Oct. 28	77.2	77	Nov. 30	77.0	74
26	74.5	46	29	77.2	77	Dec. 1	76.7	70
27	74.4	45	30	77.2	77	2	76.5	68
28	74.3	44	31	77.2	77	3	76.3	65
29	74.3	44	Nov. 1	77.2	77	4	76.2	64
30	74.2	43	2	77.1	75	5	75.9	60
Oct. 1	74.2	43	3	77.1	75	6	75.8	59
2	74.2	43	4	76.9	72	7	75.1	52
3	74.2	43	5	76.7	70	8	74.6	47
4	74.2	43	6	76.5	68	9	74.0	41
5	74.1	42	7	76.3	65	10	73.6	37
6	74.1	42	8	76.2	64	11	72.6	27
7	74.1	42	9	76.0	62	12	71.6	17
8	74.1	42	10	76.0	62	13	71.7	18
9	74.1	42	11	76.0	62	14	72.2	23
10	74.2	43	12	76.0	62	15	72.1	22
11	74.2	43	13	75.9	60	16	73.0	31
12	74.4	45	14	75.8	59	17	71.9	20
13	74.7	48	15	75.7	58	18	72.0	21
14	74.7	48	16	75.6	57	19	71.7	18
15	74.7	48	17	76.2	64	20	72.4	25
16	75.1	52	18	76.4	66	21	73.2	33
17	75.6	57	19	76.5	68	22	74.0	41
18	76.0	62	20	76.6	69	23	74.8	49
19	76.2	64	21	76.7	70	24	75.1	52
20	76.2	64	22	76.7	70	25	75.2	53
21	76.2	64	23	76.8	71	26	75.5	56
22	76.3	65	24	76.9	72	27	75.6	57
23	76.6	69	25	77.1	75	28	75.9	60
24	76.7	70	26	77.1	75	29	76.0	62
25	76.9	72	27	77.2	77	30	76.0	62
26	77.0	74	28	77.2	77	31	75.8	59
27	77.2	77	29	77.2	77			

Table showing daily discharge of the Mississippi River at Grafton, Ill., January 1, 1882, *to January* 1, 1883.

[Computed from the gauge readings by a formula deduced from discharge observations at the same point in 1881.]

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.
1882.			1882.			1882.		
Jan. 1	23.7	153	Jan. 27	18.3	75	Feb. 22	29.7	270
2	23.0	142	28	18.3	75	23	29.2	259
3	22.6	135	29	18.1	73	24	26.2	197
4	22.3	131	30	17.9	70	25	24.7	170
5	22.0	126	31	18.2	74	26	22.9	141
6	21.7	121	Feb. 1	18.3	75	27	21.8	122
7	21.3	115	2	18.5	77	28	21.3	115
8	21.0	110	3	18.3	75	Mar. 1	21.7	121
9	21.1	112	4	18.2	74	2	22.1	127
10	21.0	110	5	18.7	79	3	21.9	124
11	20.9	109	6	18.7	79	4	22.0	126
12	20.7	106	7	18.7	79	5	22.2	129
13	20.6	105	8	18.7	79	6	22.5	134
14	20.6	105	9	18.8	80	7	22.7	137
15	20.6	105	10	18.0	81	8	23.0	142
16	20.0	96	11	18.7	79	9	23.3	147
17	19.6	90	12	18.5	77	10	24.2	161
18	19.2	85	13	18.6	78	11	25.1	177
19	18.9	81	14	18.6	78	12	25.6	186
20	18.7	79	15	18.6	78	13	25.4	183
21	18.3	75	16	18.5	77	14	25.0	176
22	18.0	72	17	18.9	81	15	24.7	170
23	17.9	70	18	19.1	84	16	24.4	165
24	18.0	72	19	19.3	86	17	24.3	163
25	18.3	75	20	24.5	167	18	24.2	161
26	18.3	75	21	28.7	247	19	24.2	161

Table showing daily discharge of the Mississippi River at Grafton, Ill., &c.—Continued.

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.
1882.			1882.			1882.		
Mar. 20	24.4	165	June 5	32.0	324	Aug. 21	18.8	80
21	24.6	168	6	32.0	324	22	18.6	78
22	25.1	177	7	32.1	326	23	18.5	77
23	25.2	179	8	32.1	326	24	18.4	76
24	25.2	179	9	31.9	321	25	18.4	76
25	25.2	179	10	31.5	312	26	18.4	76
26	25.1	177	11	31.2	305	27	18.3	75
27	25.1	177	12	30.6	290	28	18.1	73
28	25.0	176	13	30.4	285	29	17.9	70
29	25.0	176	14	30.4	285	30	17.7	68
30	25.1	177	15	30.6	290	31	17.5	66
31	25.1	177	16	30.8	295	Sept. 1	17.7	68
Apr. 1	25.1	177	17	31.3	307	2	17.9	70
2	25.2	179	18	31.7	317	3	17.7	68
3	25.3	181	19	31.6	314	4	17.7	68
4	25.5	185	20	31.2	305	5	17.7	68
5	25.6	186	21	30.9	297	6	17.9	70
6	25.5	185	22	30.7	292	7	17.9	70
7	25.5	185	23	30.3	283	8	18.1	73
8	25.3	181	24	30.1	279	9	18.3	75
9	25.6	186	25	29.7	270	10	18.4	76
10	25.5	185	26	29.4	263	11	18.4	76
11	25.8	190	27	29.7	270	12	18.4	76
12	26.1	195	28	30.1	279	13	18.2	74
13	26.4	201	29	30.7	292	14	18.1	73
14	26.8	209	30	31.5	312	15	18.0	72
15	27.1	215	July 1	32.5	336	16	17.8	69
16	27.4	221	2	33.1	350	17	17.8	69
17	27.5	223	3	34.0	374	18	17.5	66
18	27.9	231	4	34.5	387	19	17.3	64
19	27.8	22[illegible]	5	34.7	392	20	17.2	63
20	27.2	217	6	34.7	392	21	17.1	62
21	27.1	215	7	34.5	387	22	16.9	60
22	27.3	219	8	34.2	379	23	16.7	58
23	28.3	239	9	33.7	366	24	16.6	57
24	29.1	257	10	33.0	348	25	16.5	56
25	29.6	268	11	32.3	331	26	16.4	55
26	30.2	281	12	31.7	317	27	16.3	54
27	30.6	290	13	30.9	297	28	16.1	52
28	30.8	295	14	30.2	281	29	16.1	52
29	31.1	302	15	29.5	266	30	16.0	51
30	31.2	305	16	28.9	252	Oct. 1	15.9	50
May 1	31.2	305	17	28.3	239	2	15.9	50
2	31.1	302	18	27.9	231	3	15.8	49
3	30.9	297	19	27.4	221	4	15.7	48
4	30.6	290	20	27.0	213	5	15.7	48
5	30.2	281	21	26.5	203	6	15.7	48
6	29.6	268	22	25.2	179	7	15.6	47
7	28.5	243	23	24.8	172	8	15.6	47
8	28.5	243	24	24.6	168	9	15.6	47
9	30.3	283	25	24.4	165	10	15.6	47
10	30.4	285	26	24.0	158	11	15.7	48
11	31.1	302	27	23.5	150	12	15.7	48
12	31.3	307	28	23.1	143	13	15.7	48
13	31.3	307	29	22.8	139	14	15.9	50
14	31.3	307	30	22.6	135	15	16.2	53
15	31.2	305	31	22.3	131	16	16.3	54
16	31.1	302	Aug. 1	22.1	127	17	16.4	55
17	31.0	300	2	22.0	126	18	16.9	60
18	30.6	290	3	22.0	126	19	17.5	66
19	30.7	292	4	21.9	124	20	17.7	68
20	30.4	285	5	21.7	121	21	17.8	69
21	30.0	277	6	21.7	121	22	17.9	70
22	28.5	243	7	21.9	124	23	18.0	72
23	28.9	252	8	21.9	124	24	18.0	72
24	28.1	235	9	21.8	122	25	18.1	73
25	27.9	231	10	21.5	118	26	18.1	73
26	27.0	218	11	21.2	113	27	18.2	74
27	27.1	215	12	20.8	108	28	18.4	76
28	28.2	237	13	20.4	102	29	18.6	78
29	29.3	261	14	20.1	97	30	18.7	79
30	29.9	274	15	19.9	94	31	18.8	80
31	30.6	290	16	19.8	93	Nov. 1	18.9	81
June 1	31.3	307	17	19.7	92	2	18.9	81
2	31.5	312	18	19.5	89	3	18.8	80
3	31.8	319	19	19.2	85	4	18.7	79
4	32.0	324	20	19.0	83	5	18.6	78

Table showing daily discharge of the Mississippi River at Grafton, Ill., &c.—Continued.

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.
1882.			1882.			1882.		
Nov. 6	18.5	77	Nov. 25	18.8	80	Dec. 14	13.8	31
7	18.2	74	26	18.9	81	15	13.8	31
8	18.1	73	27	18.9	81	16	14.0	33
9	18.0	72	28	19.0	83	17	14.2	34
10	17.8	69	29	19.1	84	18	14.2	34
11	17.7	68	30	19.2	85	19	14.4	36
12	17.6	67	Dec. 1	19.3	86	20	14.7	39
13	17.7	68	2	19.2	85	21	14.7	39
14	17.9	70	3	18.5	77	22	15.1	42
15	17.8	69	4	18.2	74	23	15.9	50
16	17.7	68	5	17.9	70	24	16.4	55
17	17.8	69	6	17.5	66	25	16.9	60
18	17.8	69	7	17.2	63	26	17.3	64
19	18.1	73	8	16.7	58	27	17.5	66
20	18.2	74	9	16.2	53	28	17.5	66
21	18.4	76	10	15.2	43	29	17.6	67
22	18.4	76	11	14.8	40	30	17.7	68
23	18.6	78	12	14.2	34	31	17.7	68
24	18.6	78	13	14.0	33			

Table showing daily discharge of Mississippi River at Fulton, Tenn., January 1, 1881, *to January* 1, 1883.

[Computed from the gauge readings by a formula deduced from discharge observations at the same point extending from November, 1879, to November, 1880.]

NOTE.—I in the column of remarks means that gauge-readings were interpolated.

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Remarks.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Remarks.
1881.				1881.			
Jan. 9	157.86	109		Feb. 17	182.58	876	
10	157.86	109		18	183.03	895	
11	158.10	114	I.	19	183.37	910	
12	158.34	119	I.	20	183.76	928	
13	158.69	126		21	184.15	947	
14	159.54	142		22	184.53	963	
15	160.89	170		23	184.89	982	
16	163.13	218		24	185.18	996	
17	164.50	252		25	185.45	1,010	
18	165.30	273	I.	26	185.61	1,018	
19	166.10	295	I.	27	185.83	1,027	
20	166.90	318	I.	28	185.94	1,032	
21	167.71	337		Mar. 1	185.92	1,031	
22	169.00	377		2	185.83	1,027	
23	171.10	442		3	185.61	1,016	I.
24	173.14	507		4	185.39	1,007	
25	174.89	568		5	184.90	982	
26	176.15	616		6	184.07	944	
27	177.05	648		7	182.89	889	
28	177.65	672		8	181.48	827	
29	178.02	687		9	180.01	767	
30	178.14	691		10	178.75	716	
31	177.84	680		11	178.16	692	
Feb. 1	177.03	648		12	177.27	657	
2	176.01	610		13	176.69	637	
3	174.87	549		14	176.29	621	
4	172.62	488		15	176.10	614	
5	170.99	439		16	176.06	613	
6	169.58	395		17	177.22	655	
7	168.44	359		18	178.09	690	
8	167.64	335		19	178.68	713	
9	167.36	327		20	179.28	738	
10	167.57	332		21	180.20	775	
11	171.85	464	I.	22	181.26	818	
12	174.08	538	I.	23	182.27	862	
13	177.00	647	I.	24	182.65	879	
14	179.40	743		25	183.09	899	
15	181.30	820		26	183.38	911	
16	181.96	847		27	183.56	919	

Table showing daily discharge of the Mississippi River at Fulton, Tenn., &c.—Continued.

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Remarks.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Remarks.
1881.				1881.			
Mar. 28	183.71	926		June 14	170.26	412	
29	183.84	932		15	170.88	434	
30	184.83	979		16	171.58	456	
31	183.75	928		17	172.32	478	
Apr. 1	183.45	914		18	172.96	499	
2	183.20	903		19	173.96	533	
3	182.95	891		20	174.96	570	
4	182.87	887		21	176.27	620	
5	182.76	883		22	176.86	642	L
6	182.53	874		23	177.45	664	
7	182.30	863		24	177.54	668	
8	181.99	850		25	177.35	660	
9	181.65	835		26	176.59	633	
10	181.67	835		27	176.34	622	
11	181.92	846		28	175.77	601	
12	182.41	868		29	175.19	580	
13	182.95	891		30	174.64	558	
14	183.49	917		July 1	174.18	542	
15	184.10	945		2	173.71	524	
16	184.68	971		3	173.29	510	
17	185.18	996		4	173.08	503	
18	185.68	1,020		5	173.25	508	
19	186.11	1,040		6	173.43	514	
20	186.46	1,058		7	173.61	520	L
21	186.78	1,074		8	173.68	523	L
22	187.12	1,090		9	173.57	519	
23	187.33	1,099		10	173.15	505	
24	187.79	1,121		11	172.53	485	
25	187.99	1,131		12	171.67	458	
26	188.09	1,136	High water.	13	170.71	427	
27	188.07	1,135		14	169.78	400	
28	187.98	1,130		15	168.93	374	
29	187.96	1,129		16	168.23	353	
30	187.85	1,123		17	167.96	345	
May 1	187.67	1,114		18	168.02	346	
2	187.35	1,100		19	168.31	355	
3	187.18	1,093		20	168.60	364	
4	187.05	1,087		21	168.84	371	
5	186.99	1,085		22	169.00	377	
6	186.94	1,082		23	169.23	384	
7	186.93	1,082		24	169.41	389	
8	186.95	1,082		25	169.49	392	
9	186.97	1,083		26	169.52	393	
10	187.05	1,087		27	169.44	390	
11	187.07	1,086		28	169.20	383	
12	187.00	1,085		29	168.97	376	
13	186.87	1,078		30	168.49	361	
14	186.53	1,067		31	167.74	338	
15	185.90	1,030		Aug. 1	167.04	321	
16	185.07	990		2	166.37	303	
17	184.08	944		3	165.88	289	
18	183.05	896		4	165.50	279	
19	181.68	836		5	165.29	273	
20	180.73	796		6	165.08	267	
21	179.59	750		7	164.89	263	
22	178.69	714		8	164.71	257	
23	177.92	683		9	164.49	252	
24	177.18	651		10	164.20	244	
25	176.35	623		11	163.84	236	
26	175.78	600		12	163.42	224	
27	175.31	583		13	163.06	217	
28	175.07	575		14	162.63	207	
29	174.86	566		15	162.27	199	
30	174.55	554		16	161.90	191	
31	174.02	537		17	161.78	188	
June 1	173.36	511		18	161.53	183	
2	172.69	491		19	161.41	181	
3	171.96	468		20	161.10	175	
4	171.37	450		21	162.53	205	
5	170.97	438		22	161.96	192	
6	170.58	422		23	161.81	189	
7	170.50	420		24	161.66	186	
8	170.64	424		25	161.53	183	
9	170.78	430	L	26	161.41	181	
10	170.72	428		27	161.31	179	
11	170.48	419		28	160.02	151	
12	170.26	412		29	158.82	128	
13	170.18	410		30	159.68	145	

Table showing daily discharge of the Mississippi River at Fulton, Tenn., &c.—Continued.

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Remarks.
1881.			
Aug. 31	159.50	142	
Sept. 1	159.36	139	
2	159.14	134	
3	159.02	132	
4	158.90	130	
5	158.83	129	
6	158.69	126	
7	158.66	126	I.
8	158.63	125	
9	158.59	124	
10	158.45	121	
11	....	....	From September 10 to December 6 no gauge readings taken.
12	....	....	
13	....	....	
14	....	....	
15	....	....	
16	....	....	
17	....	....	
18	....	....	
19	....	....	
20	....	....	
21	....	....	
22	....	....	
23	....	....	
24	....	....	
25	....	....	
26	....	....	
27	....	....	
28	....	....	
29	....	....	
30	....	....	
Oct. 1	....	....	
2	....	....	
3	....	....	
4	....	....	
5	....	....	
6	....	....	
7	....	....	
8	....	....	
9	....	....	
10	....	....	
11	....	....	
12	....	....	
13	....	....	
14	....	....	
15	....	....	
16	....	....	
17	....	....	
18	....	....	
19	....	....	
20	....	....	
21	....	....	
22	....	....	
23	....	....	
24	....	....	
25	....	....	
26	....	....	
27	....	....	
28	....	....	
29	....	....	
30	....	....	
31	....	....	
Nov. 1	....	....	
2	....	....	
3	....	....	
4	....	....	
5	....	....	
6	....	....	
7	....	....	
8	....	....	
9	....	....	
10	....	....	
11	....	....	
12	....	....	
13	....	....	
14	....	....	

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Remarks.
1881.			
Nov. 15	....	....	From September 10 to December 6 no gauge readings taken.
16	....	....	
17	....	....	
18	....	....	
19	....	....	
20	....	....	
21	....	....	
22	....	....	
23	....	....	
24	....	....	
25	....	....	
26	....	....	
27	....	....	
28	....	....	
29	....	....	
30	....	....	
Dec. 1	....	....	
2	....	....	
3	....	....	
4	....	....	
5	....	....	
6	23.42	667	
*7	22.27	624	
8	20.86	570	
9	19.69	528	
10	18.60	491	
11	17.65	461	
12	16.88	438	
13	16.27	416	
14	15.80	403	
15	15.35	390	
16	15.13	384	
17	15.06	381	
18	15.38	391	
19	16.24	415	
20	17.64	461	
21	19.21	510	
22	20.93	578	
23	22.56	635	
24	23.77	680	
25	24.68	717	
26	25.83	764	
27	27.11	816	
28	28.18	860	
29	28.97	898	
30	29.51	921	
31	29.83	939	
1882.			
Jan. 1	30.03	946	
2	30.12	950	
3	30.14	951	
4	30.17	953	
5	30.11	950	
6	30.07	948	
7	29.53	922	
8	29.75	932	
9	29.50	921	
10	29.28	912	
11	29.25	910	
12	29.24	910	
13	29.50	921	
14	29.83	939	
15	30.33	959	
16	30.91	987	
17	31.41	1,011	
18	31.85	1,032	
19	32.23	1,052	
20	32.59	1,069	
21	33.12	1,095	
22	33.54	1,113	
23	33.92	1,132	
24	34.36	1,153	
25	34.72	1,172	
26	35.02	1,189	
27	35.32	1,207	
28	35.50	1,217	

* Low water 1872 (154.12) = zero of gauge established December, 1881.

Table showing daily discharge of Mississippi River at Fulton, Tenn., &c.—Continued.

Date.		Gauge.	Discharge in 1,000 cubic feet per second.	Remarks.	Date.		Gauge.	Discharge in 1,000 cubic feet per second.	Remarks.
1882.					1882.				
Jan.	29	35.62	1,224		Apr.	17	27.81	845	
	30	35.67	1,226			18	27.88	848	
	31	35.78	1,234			19	27.92	851	
Feb.	1	35.74	1,231			20	27.61	837	
	2	35.71	1,229			21	27.08	815	
	3	35.74	1,231			22	26.24	781	
	4	35.74	1,231			23	25.61	755	
	5	35.65	1,226			24	24.70	718	
	6	35.65	1,226			25	24.06	692	
	7	35.64	1,226			26	23.93	687	
	8	35.66	1,226			27	23.82	683	
	9	35.69	1,228			28	23.96	688	
	10	35.67	1,226			29	24.21	698	
	11	35.59	1,223			30	24.46	708	
	12	35.50	1,217		May	1	24.73	719	
	13	35.51	1,217			2	24.87	724	
	14	35.37	1,211			3	24.96	729	
	15	35.28	1,201			4	25.11	735	
	16	35.18	1,199			5	25.22	740	
	17	35.11	1,194			6	25.25	741	
	18	35.05	1,191			7	25.05	733	
	19	35.03	1,190			8	24.86	724	
	20	35.12	1,194			9	24.63	715	
	21	35.17	1,199			10	25.35	745	
	22	35.23	1,201			11	27.02	818	
	23	35.32	1,207			12	28.58	880	
	24	35.59	1,222			13	29.88	939	
	25	35.89	1,239			14	30.85	984	
	26	36.19	1,255			15	31.63	1,022	
	27	36.43	1,268			16	32.16	1,047	
	28	36.63	1,278			17	32.52	1,066	
Mar.	1	36.69	1,282			18	32.67	1,073	
	2	36.66	1,279			19	32.70	1,075	
	3	36.60	1,277			20	32.69	1,076	
	4	36.51	1,272			21	32.85	1,082	
	5	36.44	1,269			22	32.83	1,081	
	6	36.44	1,269			23	32.79	1,080	
	7	36.38	1,266			24	32.81	1,080	
	8	36.28	1,260			25	32.80	1,080	
	9	36.26	1,259			26	32.68	1,074	
	10	36.18	1,255			27	32.51	1,065	
	11	36.11	1,250			28	32.14	1,047	
	12	36.04	1,247			29	31.59	1,021	
	13	36.04	1,247			30	31.04	994	
	14	36.13	1,251			31	30.66	975	
	15	36.13	1,251		June	1	30.66	975	
	16	36.00	1,245			2	30.81	982	
	17	35.86	1,237			3	31.00	992	
	18	35.76	1,232			4	31.27	1,006	
	19	35.68	1,226			5	31.55	1,018	
	20	35.62	1,224			6	31.71	1,026	
	21	35.52	1,218			7	31.85	1,032	
	22	35.44	1,214			8	31.97	1,039	
	23	35.17	1,197			9	32.04	1,042	
	24	34.97	1,187			10	32.07	1,044	
	25	34.73	1,172			11	32.07	1,044	
	26	34.49	1,160			12	31.96	1,039	
	27	34.25	1,148			13	31.69	1,026	
	28	33.96	1,133			14	31.25	1,005	
	29	33.68	1,120			15	30.50	967	
	30	33.42	1,108			16	29.49	921	
	31	33.25	1,100			17	28.45	874	
Apr.	1	33.11	1,094			18	27.45	830	
	2	32.96	1,087			19	27.90	850	
	3	32.84	1,082			20	27.21	820	
	4	32.70	1,075			21	27.86	847	
	5	32.58	1,069			22	28.59	881	
	6	32.30	1,055			23	29.01	899	
	7	31.79	1,030			24	29.35	914	
	8	31.10	997			25	29.61	926	
	9	30.16	950			26	29.79	935	
	10	29.33	918			27	29.81	935	
	11	29.05	901			28	29.69	930	
	12	28.79	889			29	29.39	917	
	13	28.62	882			30	29.09	903	
	14	28.41	872		July	1	28.56	879	
	15	28.05	856			2	28.37	870	
	16	27.87	848			3	28.26	865	

Table showing daily discharge of Mississippi River at Fulton, Tenn., &c.—

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Remarks.	Date.	Gauge.	Discharg in 1,000 cubic feet per second
1882.				1882.		
July 4	28.39	868		Sept. 20	12.47	309
5	28.62	882		21	13.02	322
6	28.89	894		22	13.60	337
7	29.20	906		23	13.52	334
8	29.58	921		24	13.01	322
9	29.82	936		25	12.33	305
10	30.06	946		26	11.84	291
11	30.18	950		27	11.30	276
12	30.12	950		28	10.76	261
13	29.89	940		29	10.30	248
14	28.74	887		30	9.85	238
15	28.41	872	I.	Oct. 1	9.53	230
16	28.04	856		2	9.31	224
17	27.30	824		3	9.02	218
18	26.61	795		4	8.84	214
19	25.82	764		5	8.75	212
20	25.02	732		6	8.79	213
21	24.31	702		7	8.79	213
22	23.69	678		8	8.77	212
23	23.17	657		9	8.70	211
24	22.70	641		10	8.63	210
25	22.15	619		11	8.60	209
26	21.40	590		12	8.58	208
27	20.52	557		13	8.57	208
28	19.50	520		14	8.48	207
29	18.64	492		15	8.40	205
30	18.87	500		16	8.30	202
31	18.22	478		17	8.20	200
Aug. 1	17.52	457		18	8.01	196
2	17.31	451		19	7.93	195
3	17.00	442		20	7.82	192
4	16.74	433		21	7.73	190
5	16.43	421		22	7.70	189
6	16.41	420		23	7.76	190
7	16.76	433		24	7.87	193
8	17.62	460		25	7.98	196
9	18.34	482		26	8.05	197
10	18.58	490		27	8.08	198
11	18.54	488		28	8.06	198
12	18.39	484		29	8.10	198
13	18.15	476		30	8.13	198
14	17.78	465		31	8.18	199
15	17.63	461		Nov. 1	8.30	202
16	17.15	446		2	8.30	202
17	16.40	420		3	8.33	203
18	15.84	404		4	8.38	204
19	15.60	398		5	8.47	206
20	15.36	390		6	8.51	207
21	15.11	383		7	8.50	207
22	14.83	374		8	8.51	20
23	14.44	362		9	8.54	20
24	13.97	348		10	8.54	20
25	13.55	335		11	8.77	21
26	13.06	323		12	9.11	22
27	12.62	314		13	9.18	22
28	12.21	301		14	9.39	22
29	11.91	292		15	9.59	23
30	11.74	288		16	9.70	23
31	11.54	282		17	9.68	23
Sept. 1	11.42	279		18	9.74	23
2	11.42	279		19	9.86	23
3	11.42	279		20	9.90	24
4	11.41	279		21	9.78	23
5	11.41	279		22	9.62	23
6	11.48	280		23	9.54	23
7	11.61	284		24	9.41	22
8	11.75	288		25	9.22	22
9	11.95	293		26	9.18	22
10	12.10	298		27	9.12	22
11	12.13	299		28	9.08	2
12	12.01	295		29	9.03	2
13	11.85	291		30	9.08	2
14	11.65	286		Dec. 1	9.09	2
15	11.47	280		2	9.10	2
16	11.19	273		3	9.11	2
17	11.00	268		4	9.12	2
18	11.02	268		5	9.11	2
19	11.57	283		6	9.11	2

Table showing daily discharge of Mississippi River at Fulton, Tenn., &c.—Continued.

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Remarks.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Remarks.
1882.				1882.			
Dec. 7	9.25	223		Dec. 20	6.64	167	
8	9.46	228		21	6.65	167	
9	9.50	229		22	6.78	169	
10	9.34	225		23	7.12	177	
11	9.06	219		24	7.70	189	
12	8.74	212		25	8.25	201	
13	8.47	206		26	8.86	215	
14	8.17	200		27	9.61	232	
15	7.86	193		28	10.48	254	
16	7.47	184		29	11.26	274	
17	7.22	179		30	11.87	291	
18	7.04	176		31	12.31	304	
19	6.78	169					

Table showing daily discharge of the Mississippi River at Memphis, Tenn., January 1, 1881, *to January* 1, 1883.

[Computed from the gauge readings, by a formula deduced from discharge observations at Hampton Landing, Ark., 1879–1880 (12 miles below Memphis), and transferred to Memphis by simultaneous gauge readings.]

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.
1881.			1881.			1881.		
Jan. 1	....	....	Feb. 16	27.20	850	Apr. 3	28.80	914
2	6.45	211	17	28.00	882	4	28.50	902
3	5.55	193	18	28.60	906	5	28.50	902
4	4.85	169	19	29.10	926	6	28.40	898
5	3.50	152	20	29.50	943	7	28.10	886
6	2.95	141	21	29.80	955	8	28.00	882
7	2.70	136	22	30.10	969	9	27.80	874
8	2.55	133	23	30.50	985	10	27.60	866
9	2.45	131	24	30.70	993	11	27.40	858
10	2.35	129	25	31.00	1,005	12	27.40	858
11	2.33	130	26	31.00	1,005	13	28.40	898
12	2.33	130	27	31.20	1,014	14	28.80	914
13	2.62	134	28	31.50	1,026	15	29.40	939
14	3.22	126	Mar. 1	31.60	1,030	16	29.90	960
15	4.04	163	2	31.70	1,034	17	30.40	981
16	5.80	198	3	31.70	1,034	18	30.80	997
17	7.90	249	4	31.40	1,022	19	31.20	1,014
18	9.30	279	5	31.10	1,009	20	31.50	1,026
19	10.40	309	6	30.50	1,026	21	31.80	1,038
20	11.30	336	7	29.80	955	22	32.20	1,057
21	12.30	360	8	28.70	910	23	32.50	1,072
22	13.30	385	9	27.30	854	24	32.75	1,084
23	15.50	451	10	25.70	792	25	33.00	1,097
24	17.50	508	11	24.40	744	26	33.20	1,105
25	19.50	573	12	23.50	711	27	33.30	1,109
26	20.90	621	13	22.80	687	28	33.30	1,109
27	22.20	666	14	22.20	666	29	33.20	1,105
28	23.00	693	15	21.70	650	30	33.15	1,103
29	23.60	715	16	21.70	650	May 1	33.05	1,099
30	23.95	727	17	22.10	662	2	33.00	1,097
31	23.95	727	18	22.80	687	3	32.85	1,089
Feb. 1	23.50	711	19	23.50	711	4	32.75	1,084
2	22.60	680	20	24.10	733	5	32.65	1,079
3	21.40	641	21	24.70	755	6	32.55	1,074
4	19.80	583	22	25.90	800	7	32.55	1,074
5	18.00	525	23	26.80	836	8	32.55	1,074
6	16.50	482	24	27.60	866	9	32.60	1,077
7	14.90	431	25	28.10	886	10	32.65	1,079
8	13.70	397	26	28.50	902	11	32.65	1,079
9	12.90	374	27	28.80	914	12	32.60	1,077
10	13.20	382	28	29.10	926	13	32.60	1,077
11	13.70	397	29	29.30	935	14	32.45	1,069
12	15.00	434	30	29.30	935	15	32.15	1,054
13	19.50	573	31	29.40	939	16	31.75	1,036
14	23.00	693	Apr. 1	29.20	930	17	31.00	1,005
15	25.80	796	2	29.00	922	18	30.10	969

Table showing daily discharge of the Mississippi River at Memphis, Tenn., &c.—Continued.

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.
1881.			1881.			1881.		
May 19	29.00	922	Aug. 5	9.50	284	Oct. 22	12.40	362
20	27.80	874	6	9.20	276	23	12.50	364
21	26.70	832	7	9.00	271	24	13.70	397
22	25.40	780	8	8.80	267	25	14.50	419
23	24.40	744	9	8.60	263	26	15.10	437
24	23.50	711	10	8.30	255	27	15.50	451
25	22.60	680	11	8.00	249	28	16.00	469
26	21.80	658	12	7.50	237	29	16.20	474
27	21.20	634	13	7.10	228	30	16.40	477
28	20.80	617	14	6.70	216	31	16.40	477
29	20.20	597	15	6.30	208	Nov. 1	16.30	477
30	20.00	590	16	5.80	198	2	16.00	469
31	19.70	579	17	5.50	192	3	15.80	461
June 1	19.20	563	18	5.10	184	4	15.70	457
2	18.40	537	19	4.80	178	5	15.80	561
3	17.60	511	20	4.60	174	6	16.00	469
4	16.80	489	21	4.50	172	7	16.10	472
5	16.10	472	22	4.40	170	8	16.40	479
6	15.50	451	23	4.35	169	9	17.00	493
7	15.20	441	24	4.30	168	10	17.40	502
8	15.10	437	25	4.10	164	11	17.80	517
9	15.30	444	26	3.90	160	12	17.90	522
10	15.35	446	27	3.80	158	13	18.00	525
11	15.20	441	28	3.70	156	14	18.20	531
12	15.00	434	29	3.65	155	15	18.70	547
13	14.80	428	30	3.40	150	16	19.30	567
14	14.80	428	31	3.30	148	17	19.90	586
15	15.00	434	Sept. 1	3.10	144	18	20.50	607
16	15.70	457	2	2.90	140	19	21.00	625
17	16.50	482	3	2.80	138	20	21.80	653
18	17.30	502	4	2.70	136	21	22.60	680
19	18.00	525	5	2.50	132	22	23.40	707
20	19.10	560	6	2.40	130	23	24.20	736
21	20.40	604	7	2.35	131	24	24.70	755
22	21.50	644	8	2.30	128	25	25.10	769
23	22.30	669	9	2.25	127	26	25.25	774
24	22.70	683	10	2.20	126	27	25.25	774
25	22.80	687	11	2.10	124	28	25.10	769
26	22.60	680	12	2.10	124	29	25.10	769
27	22.10	662	13	2.20	126	30	25.20	773
28	21.60	647	14	2.20	126	Dec. 1	25.20	773
29	20.90	621	15	2.30	128	2	25.20	773
30	20.30	600	16	2.40	130	3	25.10	769
July 1	19.70	579	17	2.50	132	4	24.80	759
2	19.20	563	18	2.60	134	5	24.30	740
3	18.70	547	19	2.80	138	6	23.40	707
4	18.30	534	20	2.90	140	7	22.40	673
5	18.10	528	21	3.20	146	8	21.10	628
6	18.20	531	22	3.70	156	9	19.70	579
7	18.45	538	23	4.10	164	10	18.40	537
8	18.70	547	24	4.20	166	11	17.20	499
9	18.70	547	25	4.30	168	12	16.00	469
10	18.50	540	26	4.30	168	13	15.20	441
11	18.00	525	27	4.30	168	14	14.60	422
12	17 30	502	28	4.90	180	15	14.00	406
13	16.40	479	29	5.80	198	16	13.50	391
14	15.30	444	30	6.10	204	17	13.40	388
15	14.20	411	Oct. 1	6.20	206	18	13.40	388
16	13.20	382	2	6.25	207	19	13.30	385
17	12.50	364	3	6.30	208	20	15.00	434
18	12.30	360	4	6.50	212	21	16.40	479
19	12.30	360	5	6.90	222	22	18.10	528
20	12.30	360	6	7.80	245	23	20.00	590
21	13.00	376	7	8.90	269	24	21.60	647
22	13.30	385	8	10.00	297	25	23.00	693
23	13.50	391	9	10.80	321	26	24.20	736
24	13.70	397	10	11.30	336	27	25.30	776
25	13.90	403	11	11.70	346	28	26.50	824
26	14.00	406	12	12.20	358	29	27.40	858
27	13.90	403	13	12.60	366	30	28.10	886
28	13.80	400	14	12.80	372	31	28.60	906
29	13.60	394	15	12.90	374	1882.		
30	13.30	385	16	13.00	376	Jan. 1	28.9	918
31	12.70	369	17	13.00	376	2	29.2	930
Aug. 1	11.90	352	18	12.90	374	3	29.3	935
2	11.10	330	19	12.70	369	4	29.4	939
3	10.40	309	20	12.50	364	5	29.4	939
4	10.30	306	21	12.40	362	6	29.3	935

Table showing daily discharge of the Mississippi River, at Memphis, Tenn., &c.—Continued.

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1.000 cubic feet per second.
1882.			1882.			1882.		
Jan. 7	29.3	935	Mar. 26	33.7	1,125	June 12	31.5	1,026
8	29.2	930	27	33.5	1,117	13	31.4	1,022
9	29.0	922	28	33.4	1,113	14	31.3	1,018
10	28.8	914	29	33.2	1,105	15	30.9	1,001
11	28.75	912	30	33.0	1,097	16	30.1	969
12	28.6	906	31	32.85	1,089	17	29.2	930
13	28.9	918	Apr. 1	32.7	1,082	18	28.4	898
14	29.1	926	2	32.55	1,074	19	27.6	866
15	29.4	939	3	32.4	1,067	20	27.2	850
16	29.8	955	4	32.4	1,067	21	27.2	850
17	30.5	967	5	32.25	1,059	22	27.8	874
18	31.0	1,005	6	32.15	1,054	23	28.5	902
19	31.4	1,022	7	31.9	1,042	24	29.0	922
20	31.7	1,034	8	31.45	1,024	25	29.2	930
21	32.0	1,047	9	30.7	993	26	29.3	935
22	32.3	1,062	10	29.9	960	27	29.4	939
23	32.7	1,082	11	29.2	930	28	29.5	943
24	32.9	1,092	12	28.8	914	29	29.5	943
25	33.2	1,105	13	28.5	902	30	29.1	926
26	33.4	1,113	14	28.3	894	July 1	28.8	914
27	33.6	1,121	15	28.0	882	2	28.5	902
28	33.9	1,133	16	27.75	872	3	28.2	890
29	34.0	1,137	17	27.5	862	4	28.1	886
30	34.1	1,142	18	27.5	862	5	28.0	882
31	34.1	1,142	19	27.6	866	6	28.0	882
Feb. 1	34.15	1,144	20	27.5	862	7	28.5	902
2	34.0	1,137	21	27.1	847	8	28.9	918
3	34.0	1,137	22	26.5	824	9	29.2	930
4	34.15	1,144	23	25.7	792	10	29.5	943
5	34.1	1,142	24	24.9	762	11	29.7	951
6	34.1	1,142	25	24.1	733	12	30.0	965
7	34.25	1,149	26	23.4	707	13	29.8	955
8	34.25	1,149	27	23.0	693	14	29.65	949
9	34.3	1,151	28	22.6	680	15	29.2	930
10	34.3	1,151	29	23.4	707	16	28.5	902
11	34.25	1,149	30	23.75	720	17	27.8	874
12	34.25	1,149	May 1	24.1	733	18	27.1	847
13	34.25	1,149	2	24.3	740	19	26.3	816
14	34.25	1,149	3	24.4	744	20	25.5	784
15	34.25	1,149	4	24.5	747	21	24.6	751
16	34.15	1,144	5	24.6	751	22	23.7	718
17	34.1	1,142	6	24.7	755	23	23.0	693
18	34.05	1,139	7	24.7	755	24	22.5	676
19	34.0	1,137	8	24.6	751	25	21.9	656
20	33.95	1,135	9	24.6	751	26	21.3	637
21	33.95	1,135	10	25.2	773	27	20.3	600
22	33.90	1,133	11	26.85	838	28	19.3	567
23	33.95	1,135	12	28.50	902	29	18.2	531
24	34.0	1,137	13	29.30	935	30	17.2	499
25	34.05	1,139	14	30.0	965	31	16.3	477
26	34.15	1,144	15	30.5	967	Aug. 1	15.5	451
27	34.2	1,147	16	31.1	1,009	2	15.0	434
28	34.55	1,162	17	31.5	1,026	3	14.5	419
Mar. 1	34.6	1,165	18	31.7	1,034	4	14.3	414
2	34.8	1,174	19	31.9	1,042	5	14.0	406
3	34.8	1,174	20	32.0	1,047	6	13.7	397
4	34.8	1,174	21	32.1	1,052	7	13.7	397
5	34.8	1,174	22	32.2	1,057	8	14.4	416
6	35.15	1,188	23	32.2	1,057	9	15.2	441
7	35.05	1,184	24	32.2	1,057	10	15.9	465
8	35.00	1,182	25	32.2	1,057	11	16.1	472
9	35.15	1,188	26	32.15	1,054	12	16.0	469
10	35.00	1,182	27	32.1	1,052	13	15.8	461
11	35.00	1,182	28	31.95	1,044	14	15.6	454
12	34.8	1,174	29	31.65	1,032	15	15.3	444
13	34.7	1,169	30	31.20	1,014	16	15.0	434
14	34.55	1,162	31	30.7	1 993	17	14.6	422
15	35.55	1,162	June 1	30.35	979	18	14.1	409
16	34.45	1,158	2	30.3	977	19	13.8	400
17	34.4	1,156	3	30.4	981	20	13.6	394
18	34.3	1,151	4	30.6	989	21	13.4	388
19	34.25	1,149	5	30.8	997	22	13.2	382
20	34.2	1,147	6	30.9	1,001	23	12.8	372
21	34.15	1,144	7	31.1	1,009	24	12.3	360
22	34.05	1,139	8	31.25	1,016	25	11.8	349
23	34.0	1,137	9	31.4	1,022	26	11.3	336
24	33.9	1,133	10	31.5	1,026	27	10.8	321
25	33.8	1,129	11	31.5	1,026	28	10.2	303

Table showing *daily discharge of Mississippi River at Memphis, Tenn., &c.*—Co

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.
1882.			1882.			1882.	
Aug. 29	9.5	284	Oct. 10	5.4	190	Nov. 21	7.25
30	9.0	271	11	5.4	190	22	7.25
31	8.9	269	12	5.4	190	23	7.00
Sep. 1	8.9	269	13	5.4	190	24	6.75
2	8.8	267	14	5.4	190	25	6.60
3	8.8	267	15	5.35	189	26	6.55
4	8.8	267	16	5.22	186	27	6.50
5	8.75	266	17	5.13	184	28	6.45
6	8.75	266	18	5.13	184	29	6.40
7	8.85	268	19	4.84	179	30	6.35
8	8.90	269	20	4.68	175	Dec. 1	6.30
9	9.25	277	21	4.55	173	2	6.25
10	9.45	282	22	4.55	173	3	6.25
11	9.55	285	23	4.47	171	4	6.30
12	9.55	285	24	4.47	171	5	6.40
13	9.40	281	25	4.84	178	6	6.40
14	9.25	277	26	4.88	180	7	6.45
15	9.00	271	27	4.97	181	8	6.60
16	8.50	260	28	4.97	181	9	6.80
17	8.30	255	29	4.97	181	10	6.60
18	8.25	254	30	4.93	181	11	6.50
19	8.25	254	31	5.01	182	12	6.25
20	9.00	271	Nov. 1	5.13	184	13	6.00
21	10.00	297	2	5.18	185	14	5.70
22	10.50	312	3	5.22	186	15	5.25
23	11.40	338	4	5.22	186	16	4.85
24	11.25	334	5	5.34	188	17	4.45
25	10.40	309	6	5.43	190	18	4.20
26	9.80	292	7	5.47	191	19	4.00
27	9.25	277	8	5.51	192	20	3.75
28	8.55	261	9	5.52	192	21	3.50
29	8.00	249	10	5.54	192	22	3.55
30	7.30	238	11	5.55	193	23	3.75
Oct. 1	6.8	219	12	5.97	201	24	4.15
2	6.3	208	13	6.18	205	25	4.90
3	6.0	202	14	6.26	207	26	5.07
4	5.8	198	15	6.47	211	27	6.30
5	5.75	197	16	6.76	217	28	7.20
6	5.45	191	17	6.85	220	29	8.20
7	5.45	191	18	7.00	225	30	9.00
8	5.4	190	19	7.10	228	31	9.70
9	5.4	190	20	7.20	230		

Table showing *daily discharge of the Mississippi River at Carrollton, La., Janua* *to January* 1, 1883.

[Computed from the gauge readings by a formula deduced from discharge observations point extending from December, 1879, to October, 1880.]

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.
1881.			1881.			1881.	
Jan. 1	....	....	Jan. 20	2.1	296	Feb. 8	10.4
2	5.3	438	21	2.0	292	9	10.4
3	5.1	428	22	2.1	296	10	10.0
4	5.6	451	23	2.4	308	11	10.1
5	5.0	424	24	3.0	333	12	9.9
6	4.6	406	25	3.2	342	13	9.6
7	4.3	393	26	3.6	361	14	9.3
8	3.9	374	27	4.1	383	15	9.3
9	3.7	365	28	4.8	415	16	9.3
10	3.5	356	29	5.6	451	17	9.4
11	2.9	329	30	6.5	492	18	9.8
12	2.5	312	31	7.2	530	19	10.3
13	2.4	308	Feb. 1	7.9	562	20	10.6
14	2.1	296	2	8.3	578	21	10.8
15	2.0	292	3	8.6	591	22	11.3
16	2.0	292	4	8.9	606	23	11.4
17	1.9	288	5	9.3	626	24	11.6
18	1.8	284	6	10.0	661	25	11.9
19	1.8	284	7	10.6	691	26	12.0

Table showing daily discharge of Mississippi River at Carrollton, La., &c.—Continued.

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.
1881.			1881.			1881.		
Feb. 27	12.3	780	May 16	12.1	769	Aug. 2	4.3	393
28	12.1	769	17	12.0	764	3	4.4	397
Mar. 1	12.2	774	18	12.1	769	4	3.9	374
2	12.0	764	19	12.1	769	5	3.6	361
3	12.1	769	20	12.1	769	6	3.3	347
4	12.2	774	21	12.25	777	7	3.2	342
5	12.2	774	22	12.3	780	8	2.8	325
6	12.1	769	23	12.3	780	9	2.5	312
7	12.2	774	24	12.3	780	10	2.1	296
8	12.0	764	25	12.3	780	11	1.9	288
9	12.0	764	26	12.4	785	12	1.7	280
10	12.2	774	27	12.3	780	13	1.7	280
11	12.3	780	28	12.3	780	14	1.7	280
12	12.4	785	29	12.3	780	15	1.6	276
13	12.3	780	30	12.4	785	16	1.8	284
14	12.4	785	31	12.3	780	17	2.0	292
15	12.5	790	June 1	12.3	780	18	2.0	292
16	12.5	790	2	12.2	774	19	1.7	280
17	12.4	785	3	12.2	774	20	1.4	267
18	12.3	780	4	12.2	774	21	1.1	255
19	12.3	780	5	12.2	774	22	1.0	251
20	12.2	774	6	12.2	774	23	1.0	251
21	12.3	780	7	12.2	774	24	0.8	242
22	11.9	758	8	12.2	774	25	0.8	242
23	12.1	769	9	12.0	764	26	1.0	251
24	12.1	769	10	12.0	764	27	1.0	251
25	12.1	769	11	11.9	758	28	0.7	238
26	12.2	774	12	11.6	742	29	0.8	242
27	12.2	774	13	11.3	726	30	0.8	242
28	12.3	780	14	11.1	716	31	1.3	263
29	12.4	785	15	10.9	706	Sept. 1	1.4	267
30	12.25	777	16	10.8	701	2	1.5	272
31	12.2	774	17	10.7	696	3	1.5	272
Apr. 1	12.2	774	18	10.5	686	4	1.4	267
2	12.2	774	19	10.3	676	5	1.3	263
3	12.2	774	20	10.2	671	6	1.1	255
4	12.3	780	21	10.1	666	7	0.8	242
5	12.3	780	22	10.0	661	8	0.7	238
6	12.3	780	23	9.75	648	9	0.5	230
7	12.3	780	24	9.6	641	10	0.3	222
8	12.4	785	25	9.6	641	11	0.4	226
9	12.4	785	26	9.6	641	12	0.6	234
10	12.4	785	27	9.6	641	13	0.8	242
11	12.4	785	28	9.8	651	14	1.15	257
12	12.55	792	29	9.9	656	15	1.5	272
13	12.5	790	30	9.95	658	16	1.1	255
14	12.3	780	July 1	9.9	656	17	1.1	255
15	12.3	780	2	9.9	656	18	1.3	263
16	12.2	774	3	10.0	661	19	1.2	259
17	12.0	764	4	10.0	661	20	1.0	251
18	12.1	769	5	9.9	656	21	0.9	246
19	12.1	769	6	9.8	651	22	0.7	238
20	12.0	764	7	9.6	641	23	0.65	236
21	12.1	769	8	9.4	631	24	0.7	238
22	12.1	769	9	9.2	621	25	0.8	242
23	12.2	774	10	9.1	616	26	1.0	251
24	12.4	785	11	8.7	596	27	1.2	259
25	12.2	774	12	8.3	578	28	1.4	267
26	12.3	780	13	8.1	570	29	1.4	267
27	12.2	774	14	7.9	562	30	1.8	284
28	12.1	769	15	7.9	562	Oct. 1	2.0	292
29	12.0	764	16	7.7	554	2	1.9	288
30	12.0	764	17	7.4	541	3	1.8	284
May 1	11.9	758	18	7.1	525	4	1.4	267
2	11.9	758	19	6.7	508	5	1.1	255
3	12.0	764	20	6.3	483	6	1.2	259
4	11.9	758	21	5.6	451	7	2.1	296
5	11.9	758	22	4.9	420	8	1.8	284
6	12.1	769	23	4.3	393	9	1.6	276
7	12.1	769	24	3.9	374	10	1.4	267
8	12.3	780	25	3.7	365	11	1.7	280
9	12.2	774	26	3.4	351	12	2.0	292
10	12.2	774	27	3.3	347	13	2.2	300
11	12.3	780	28	3.2	342	14	2.2	300
12	12.2	774	29	3.3	347	15	2.4	308
13	12.1	769	30	3.4	351	16	2.5	312
14	12.2	774	31	3.4	351	17	2.7	320
15	12.2	774	Aug. 1	3.9	374	18	2.75	322

Table showing daily discharge of Mississippi River at Carrollton, La., &c.—Continued.

Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.
1881.			1882.			1882.	
Oct. 19	2.75	322	Jan. 4	9.9	656	Mar. 23	14.65
20	2.75	322	5	10.0	661	24	14.65
21	2.85	327	6	10.4	681	25	14.8
22	2.9	329	7	10.7	696	26	14.8
23	2.9	329	8	10.9	706	27	14.95
24	3.0	333	9	11.1	716	28	14.9
25	2.9	329	10	11.2	721	29	14.75
26	2.9	329	11	11.2	721	30	14.65
27	3.0	333	12	11.2	721	31	14.6
28	3.5	356	13	11.2	721	Apr. 1	14.6
29	4.0	379	14	11.3	726	2	14.65
30	4.4	397	15	11.3	726	3	14.6
31	4.1	383	16	11.4	731	4	14.6
Nov. 1	4.1	383	17	11.7	747	5	14.6
2	4.2	388	18	11.6	742	6	14.6
3	4.2	386	19	11.7	747	7	14.4
4	4.3	393	20	11.8	758	8	14.4
5	4.4	397	21	12.1	769	9	14.2
6	4.5	402	22	12.2	774	10	14.1
7	4.9	420	23	12.3	780	11	14.1
8	4.8	415	24	12.3	780	12	14.2
9	4.8	415	25	12.5	790	13	14.3
10	4.8	415	26	12.4	785	14	14 15
11	5.0	424	27	12.3	780	15	14.15
12	5.2	433	28	12.5	790	16	14.1
13	5.2	433	29	12.6	795	17	14.0
14	5.3	438	30	12.7	800	18	14.0
15	5.3	438	31	12.7	800	19	13.9
16	5.45	444	Feb. 1	12.7	800	20	13.9
17	5.7	455	2	12.7	800	21	13.75
18	5.8	460	3	12.85	807	22	13.9
19	5.8	460	4	12.8	805	23	13.7
20	6.2	478	5	12.7	800	24	13.6
21	6.2	478	6	12.7	800	25	13.5
22	6.7	503	7	12.8	805	26	13.5
23	7.2	530	8	12.9	810	27	13.45
24	7.4	541	9	13.0	816	28	13.45
25	7.6	550	10	12.9	810	29	13.6
26	7.8	558	11	13.0	816	30	13.5
27	8.1	570	12	13.0	816	May 1	13.45
28	8.3	578	13	13.1	821	2	13.4
29	8.6	591	14	13.1	821	3	13.3
30	8.9	606	15	13.2	826	4	13.2
Dec. 1	9.0	611	16	13.2	826	5	13.2
2	9.2	621	17	13.2	826	6	13.2
3	9.4	631	18	13.3	831	7	13.1
4	9.4	631	19	13.4	836	8	13.2
5	9.5	636	20	13.4	836	9	13.1
6	9.7	646	21	13.5	842	10	13.1
7	9.7	646	22	13.4	836	11	13.2
8	9.8	651	23	13.4	836	12	13.0
9	9.9	656	24	13.4	836	13	12.9
10	9.9	656	25	13.6	848	14	12.9
11	9.8	651	26	13.7	853	15	12.9
12	9.8	651	27	13.8	858	16	12.8
13	9.6	641	28	14.0	869	17	12.7
14	9.5	636	Mar. 1	14.0	869	18	12.8
15	8.9	606	2	14.0	869	19	12.7
16	8.7	596	3	14.1	874	20	12.8
17	8.4	582	4	14.1	874	21	12.8
18	8.2	574	5	14.2	879	22	12.8
19	7.8	558	6	14.3	884	23	12.7
20	7.5	540	7	14.4	890	24	12.8
21	7.2	530	8	14.6	901	25	12.8
22	6.8	508	9	14.7	907	26	12.8
23	6.5	492	10	14.6	901	27	12.8
24	6.2	478	11	14.7	907	28	12.8
25	6.3	483	12	14.8	912	29	12.7
26	6.5	492	13	14.75	909	30	12.7
27	6.5	492	14	14.7	907	31	12.6
28	6.9	514	15	14.75	909	June 1	12.6
29	7.3	536	16	14.8	912	2	12.5
30	7.5	546	17	14.8	912	3	12.5
31	8.0	566	18	14.9	918	4	12.4
1882.			19	14 8	912	5	12.4
Jan. 1	8.5	586	20	14.9	918	6	12.4
2	8.9	606	21	14.9	918	7	12.5
3	9.5	636	22	14.8	912	8	12.7

Table showing daily discharge of the Mississippi River at Carrollton, La., &c.—Continued.

Date.	Gauge.	Discharge in 1,000 cubic feet. per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.	Date.	Gauge.	Discharge in 1,000 cubic feet per second.
1882.			1882.			1882.		
June 9	12.8	805	Aug. 17	7.9	562	Oct. 25	1.2	259
10	12.8	805	18	7.8	558	26	1.2	259
11	12.8	805	19	7.6	550	27	1.2	259
12	12.7	800	20	7.5	546	28	1.25	261
13	12.6	795	21	7.4	541	29	1.5	272
14	12.6	795	22	7.3	536	30	1.85	286
15	12.6	795	23	7.1	525	31	2.0	292
16	12.6	795	24	6.7	503	Nov. 1	2.0	292
17	12.55	792	25	6.4	487	2	1.8	284
18	12.55	792	26	6.1	474	3	1.8	284
19	12.55	792	27	5.8	460	4	1.7	280
20	12.50	790	28	5.6	451	5	1.6	276
21	12.50	790	29	5.4	442	6	1.5	272
22	12.4	785	30	5.0	424	7	1.2	259
23	12.5	790	31	4.9	420	8	1.0	251
24	12.5	790	Sept. 1	4.6	406	9	1.1	255
25	12.5	790	2	4.4	397	10	1.1	255
26	12.5	790	3			11	1.1	255
27	12.5	790	4			12	1.4	267
28	12.6	795	5			13	1.8	284
29	12.6	795	6	(*)	....	14	1.7	280
30	12.6	795	7			15	1.7	280
July 1	12.5	790	8			16	1.7	280
2	12.5	790	9			17	1.7	280
3	12.45	787	10	2.7	320	18	1.7	280
4	12.4	785	11	2.7	320	19	1.7	280
5	12.4	785	12	2.7	320	20	1.6	276
6	12.4	785	13	2.6	316	21	1.4	267
7	12.4	785	14	2.6	316	22	1.4	267
8	12.4	785	15	2.6	316	23	1.4	267
9	12.4	785	16	2.75	322	24	1.6	276
10	12.35	782	17	2.7	320	25	2.0	292
11	12.35	782	18	2.6	316	26	2.4	308
12	12.35	782	19	2.6	316	27	2.9	329
13	12.35	782	20	2.6	316	28	2.7	320
14	12.35	782	21	2.75	322	29	2.7	320
15	12.3	780	22	2.75	322	30	2.65	318
16	12.2	774	23	2.75	322	Dec. 1	2.5	312
17	12.2	774	24	2.55	314	2	2.4	308
18	12.2	774	25	2.35	306	3	2.5	312
19	12.1	769	26	2.35	306	4	2.7	320
20	12.2	774	27	2.35	306	5	2.8	325
21	12.1	769	28	2.60	316	6	2.9	329
22	12.2	774	29	2.9	329	7	2.9	329
23	12.1	769	30	3.2	342	8	3.0	333
24	12.2	774	Oct. 1	3.4	351	9	3.0	333
25	12.2	774	2	3.2	342	10	2.8	325
26	12.2	774	3	3.2	342	11	2.8	325
27	12.1	769	4	3.1	338	12	2.8	325
28	12.0	764	5	2.9	329	13	2.85	327
29	12.0	764	6	2.6	316	14	2.9	329
30	11.9	758	7	2.4	308	15	3.0	333
31	11.9	758	8	2.4	308	16	2.9	329
Aug. 1	11.7	747	9	2.4	308	17	2.9	329
2	11.7	747	10	2.2	300	18	3.0	333
3	11.5	736	11	1.9	288	19	3.0	333
4	11.5	736	12	1.5	272	20	3.2	342
5	11.4	731	13	1.4	267	21	3.0	333
6	11.1	716	14	1.5	272	22	3.1	338
7	10.8	701	15	1.5	272	23	2.9	329
8	10.5	686	16	1.6	276	24	2.9	329
9	10.0	661	17	1.8	284	25	2.6	316
10	9.7	646	18	1.7	280	26	2.4	308
11	9.3	626	19	1.9	288	27	2.2	300
12	8.9	606	20	2.2	300	28	2.0	292
13	8.5	586	21	2.0	292	29	1.9	288
14	8.3	578	22	1.7	280	30	1.8	284
15	8.1	570	23	1.5	272	31	1.8	284
16	8.0	566	24	1.25	261			

*Gauge down.

APPENDIX G.

REPORT OF ASSISTANT ENGINEER J. A. OCKERSON ON CHANGES IN MISSISSIPPI RIVER BETWEEN GRAND GULF AND DONALDSONVILLE.

OFFICE MISSISSIPPI RIVER COMMISSION,
Saint Louis, Mo., September 15, 1883.

SIR: While in the field tracings were made of local maps covering the river from Grand Gulf to New Orleans, with a view to a study of the changes that have occurred. Between Natchez and Bayou Sara special pains were taken to identify points of the old surveys and connect with them. From Grand Gulf to Fort Adams the comparisons were made with the land surveys of 1828. These maps show only the right bank as connected with the township and other lines, while the left bank has been sketched in, and does not represent correctly the width of the river. The relative positions of the river bed in 1828 and 1883 are shown in Plates 1 and 2, submitted herewith. In making these comparisons, old boundary lines, bayous, lakes, towns, roads, &c., which were common to the two surveys were used. On sheet 1 and a part of 2, the common points agreed fairly well. From Dead Man's Bend to Fort Adams the comparisons are not reliable, and from the latter point down to Red River Landing the discrepancies between the two surveys are so great that they could not be harmonized. Throughout, the comparisons must not be regarded as exact, but will serve to indicate in a general way what changes have occurred in the past.

The river at two periods 55 years apart is here compared, but there may have been greater changes during that period than are here shown. Islands and battures have doubtless been made and washed away again during the interval. For more than one-half of the length of the above reach, the present bed of the river is entirely outside of the limits of the bed of 1828, and in some cases it is several miles from it.

From Red River Landing to Donaldsonville a better comparison can be made by using the survey of Humphreys and Abbot, made in 1851. Tracings of the latter, on a scale of 1:10,000, were compared with the surveys of 1883 made by the Mississippi River Commission. Numerous points on the old survey, such as angles and straight portions of levee, plantation lines, churches, towns, roads, bayous, &c., were easily identified and agreed very closely with the surveys of 1883, and the comparisons shown on sheets 3, 4, and 5 may be considered as reliable. There was some doubt about the points in the vicinity and opposite Baton Rouge, and this reach has been omitted. The Humphreys and Abbot tracings do not show the left bank of the river above Baton Rouge except in the vicinity of Red River, and to prevent confusion this has been sketched.

The lines of the survey of 1851 came down along the old river; hence from Raccourci cut-off to New Texas we have no means of comparison.

A tracing was made of an old map from the archives at Baton Rouge, showing the bends in the vicinity of Red River as they were prior to 1810. This map showed the State line between Mississippi and Louisiana.

The position of these bends, as shown on sketch, with reference to the later surveys depends on the State line and on the river bank across Routh's Point, which is still plainly marked and apparently common to the three surveys. The relative positions are therefore approximate.

An examination of the sketches shows that—

The bends have moved down stream;

The islands have moved down stream;

The preponderance of the movement of the river as a whole has been to the west;

The bends have grown longer. From Grand Gulf to Fort Adams this lengthening amounts to about 4 miles. Below Baton Rouge the changes are comparatively slight;

The changes in the vicinity of the two cut-offs near Red River are not as great as at distant points both above and below;

The caving has been very much the greatest on the upper side of the points.

High-water widths of the river between Baton Rouge and Donaldsonville.

In Humphreys and Abbot's Report, pages 118 and 119, are given the widths of the river at numerous points. From Baton Rouge down they are given at intervals of about 4,000 feet. Most of these positions are easily identified, and the widths as given by the survey of 1883 have been measured. The results are given in a table appended herewith.

If we compare the last 68 sections we find that the mean width, according to the survey of 1851, is 2,835 feet; and from the survey of 1883 it is 2,984 feet, or an increase in thirty-two years of 149 feet. This gives an average of a little less than 5 feet per year.

Widths between high-water banks.

No.	Locality.	M. R. C., 1883.	H. & A., 1851.	Remarks.
		Feet.	*Feet.*	
....	Cole Creek Point	1,935	*2,350	*Locality uncertain
....	Natches	4,132	*4,540	*Do.
....	Ellis Cliffs	1,935	*3,250	*Do.
....	Routh's Point	3,792	3,880	
....	Mouth of Red River	4,281	3,500	
....	4,000 feet below Red River	4,329	3,600	
....	8,000 feet below Red River	3,575	3,700	
....	12,000 feet below Red River	3,936	3,000	
....	Raccourci, upper end	4,592	2,400	
....	Raccourci, lower end	3,280	2,400	
....	Tunica Bend	3,476	*3,320	*Ellet's report.
1	Baton Rouge, Arsenal	3,181	2,900	
2	Baton Rouge, State-House	2,657	2,350	
3	4,000 feet below State-House	2,460	2,200	
4	8,000 feet below State-House	2,531	2,650	
5	12,000 feet below State-House	2,313	3,025	
6	16,000 feet below State-House	3,313	2,400	
7	20,000 feet below State-House	2,859	3,100	
8	24,000 feet below State-House	3,509	3,400	
9	28,000 feet below State-House	3,673	3,000	
10	32,000 feet below State-House	3,313	2,650	
11	36,000 feet below State-House	3,575	3,250	
12	40,000 feet below State-House	3,280	3,400	
13	44,000 feet below State-House	2,574	2,250	
14	48,000 feet below State-House	2,492	2,250	
15	52,000 feet below State-House	2,771	2,475	
16	56,000 feet below State-House	2,788	2,550	
17	60,000 feet below State-House	2,624	2,500	
18	64,000 feet below State-House	2,820	2,450	
19	68,000 feet below State-House	3,903	3,700	
20	Mouth of Bayou Manchac	3,608	2,950	
21	4,000 feet below Bayou Manchac	2,558	2,400	
22	8,000 feet below Bayou Manchac	2,377	2,300	
23	12,000 feet below Bayou Manchac	2,460	2,450	
24	16,000 feet below Bayou Manchac	3,542	3,250	
25	20,000 feet below Bayou Manchac	3,345	2,900	
26	24,000 feet below Bayou Manchac	2,705	2,400	
27	Mouth of Plaquemine Bayou	2,132	2,700	
28	4,000 feet below Plaquemine Bayou	2,952	2,750	
29	8,000 feet below Plaquemine Bayou	2,689	2,575	
30	12,000 feet below Plaquemine Bayou	2,344	2,930	
31	16,000 feet below Plaquemine Bayou	2,066	2,930	
32	20,000 feet below Plaquemine Bayou	3,083	2,930	
33	24,000 feet below Plaquemine Bayou	4,296	4,400	
34	28,000 feet below Plaquemine Bayou	3,542	3,500	
35	32,000 feet below Plaquemine Bayou	2,591	2,500	
36	36,000 feet below Plaquemine Bayou	2,408	2,400	
37	40,000 feet below Plaquemine Bayou	3,033	2,850	
38	44,000 feet below Plaquemine Bayou	2,722	2,700	
39	48,000 feet below Plaquemine Bayou	2,755	2,450	
40	52,000 feet below Plaquemine Bayou	2,591	2,450	
41	56,000 feet below Plaquemine Bayou	2,655	2,800	
42	Bayou Goula	4,165	3,750	
43	4,000 feet below Bayou Goula	3,444	3,250	
44	8,000 feet below Bayou Goula	2,814	2,650	
45	12,000 feet below Bayou Goula	2,099	2,650	
46	16,000 feet below Bayou Goula	2,460	2,500	
47	20,000 feet below Bayou Goula	2,476	2,250	
48	24,000 feet below Bayou Goula	2,460	2,400	
49	28,000 feet below Bayou Goula	2,624	2,500	
50	32,000 feet below Bayou Goula	3,394	3,100	
51	36,000 feet below Bayou Goula	3,903	3,500	
52	40,000 feet below Bayou Goula	3,936	3,700	
53	Opposite Claiborne Isle	2,952	3,400	
54	4,000 feet below Claiborne Isle	3,066	2,450	
55	8,000 feet below Claiborne Isle	2,919	2,800	
56	12,000 feet below Claiborne Isle	3,181	3,100	
57	16,000 feet below Claiborne Isle	2,853	3,000	
58	20,000 feet below Claiborne Isle	2,682	2,500	
50	Ashland plantation	2,682	2,550	
60	4,000 feet below plantation	2,640	3,550	
61	8,000 feet below plantation	2,939	3,500	
62	12,000 feet below plantation	3,280	3,000	
63	16,000 feet below plantation	3,627	3,006	
64	20,000 feet below plantation	2,657	2,450	
65	21,000 feet below plantation	2,296	2,600	
66	28,000 feet below plantation	2,705	2,700	
67	32,000 feet below plantation	2,657	2,600	
68	Donaldsonville	2,952	3,300	
	Mean of 68 sections	2,984	2,835	

In order to show the relative widths to the eye, curves have been plotted with the widths as ordinates. These curves follow one another very closely till we reach No. 60, where the wide part of the river seems to have moved down-stream. The bar on the right bank has moved down-stream, but a part of this seeming discrepancy is probably due to the difficulty of identifying the high-water bank, where a rise of a few tenths of a foot would move the shore line back several hundred feet.

It will be observed that at Plaquemine and the straight reach below, the river has grown narrower. This is also partially due to the difficulty of locating the high-water bank, but mainly to the large batture which has formed on the left bank.

The above comparisons do not give any clew to the changes below the high-water line. It is evident that accurate results cannot be obtained by measuring the widths at the same identical points unless they are very close together. Where bends, islands, and bars are moving down-stream, the measurements should rather be in the same relative positions.

Comparison of cross-sections below mouth of Red River.

In accordance with your instructions, comparisons have been made with all available cross-sections of previous surveys between Red River and Donaldsonville. Sections have been selected from the surveys of 1883 whose positions are nearly identical with those of former surveys. All sections compared have been plotted, and the results are appended herewith. (See Plates 6, 7, 8, and 9.)

From the survey of Humphreys and Abbot in 1851 all the available sections have been taken, viz, three near Red River, four near Baton Rouge, and one across the Red River near its junction with the Mississippi. The data for the above has been taken from Appendix C, pages 571 and 572, Humphreys and Abbot's Report.

It will be observed that section 24, above the mouth of Red River, has remained practically the same shape, although it has moved bodily to the west nearly half a mile. (See Plates 3 and 6.) Section 25, just below the mouth of the Red River, shows a remarkable change in the form of the section, while the shape of the bend has remained nearly the same. There are no other sections of the old survey in this immediate vicinity, hence there is no means of verifying the peculiarity of the change. The nearest section below (No. 27) is about 4 miles distant, and here we find a decided deepening, amounting to 40 feet. This, however, might be expected, as the section is immediately below the cut-off, and the section of 1851 was made less than three years after the cut-off.

The sections at the Mississippi mouth of the Red River also show a decided shoaling, amounting to 20 feet.

The four sections in the vicinity of Baton Rouge do not show very much change. A comparison of these sections is given in the following table:

Comparative area of sections.

Number of H. and A. section.	Mississippi River Commission, 1883.		H. and A., 1851.		Locality.
	Maximum depth.	Area.	Maximum depth.	Area.	
	Feet.	*Feet.*	*Feet.*	*Feet.*	
24	55	128,500	59	119,500	1 mile above Red River.
25	46	137,625	102	173,250	Red River Landing.
27	125	109,425	80	125,750	4 miles below Red River.
29	85	150,750	89	151,625	Above Baton Rouge.
32	94	158,750	96	186,250	Near Convention Station.
33	88	148,000	80	147,750	600 feet below State-house.
34	85	161,375	101	166,000	1 mile below State house.
21	33	22,125	53	36,875	Mouth of Red River.

In these comparisons the water surface at time of sounding in 1883 has been used as the limiting line. The areas were measured with a polar planimeter, the mean of three determinations being used. The water surface of 1851 was reduced to the datum plane of the later survey, as follows:

Hampson bench above mean tide of Gulf, H. and A., 1851	7.92
Hampson bench above mean tide of Gulf, M. R. C., 1882	7.13
Difference between the two values	0.79

On page 107 Humphreys and Abbot Report, the elevation of the high water of 1851 above the Gulf is given as 49.5 feet. Correcting this by 0.8 foot, the difference in the two determinations of the Hampson bench above mean tide, we have, 48.7 feet as the height of the water surface at Red River Landing; or 56.7 feet above Memphis datum plane, which is 225 feet below the high water of 1858 at Memphis, Tenn., or 190.84 feet below the zero of United States Engineers' gauge at that point. It is 8.1 feet above the mean level of the Gulf.

No comparison of the benches at Red River or Baton Rouge could be made. Chief of Engineer's Report, 1872, page 433, states that "no vestige of the old United States bench remains." Report of 1873, page 522, gives zero of Baton Rouge gauge as 0.90 foot lower than theDelta Survey gauge, but the records do not show whether gague has since been changed or not. The comparisons, therefore, depend, for the Delta Survey, on a double line of levels from Carrollton to Baton Rouge, and a single line "run with the greatest care" from the latter point to Red River Landing, and for the survey of 1883 on a line of "precise levels" made by the United States Coast and Geodetic Survey; these two surveys being connected only at the lower end, on what is known as Hampson's bench-mark. It is probable that the discrepancy at Red River Landing is quite small, as the top of the levee, according to the Delta Survey, is 59 feet above the Memphis datum, and the survey of 1883 gives it as 58 to 59 feet above same datum.

Sections in the vicinity of Donaldsonville.

The next reliable sections with which comparisons can be made are in the vicinity of Donaldsonville. The soundings were made by the United States Coast and Geodetic Survey during the latter part of 1880 and the first half of 1881.

Comparison of sections between Plaquemine and Donaldsonville.

Section.		Locality.	Areas.		Maximum depth.		Difference of areas.	Reading of Baton Rouge gauge.			
1881.	1883.		1881.	1883.	1881.	1883.		Date.	Readings.	Date.	Readings.
			Sq. ft.	*Sq. ft.*	*Feet.*	*Feet.*	*Square feet.*	1881.		1883.	
O″	168	2½ miles below Plaquemine	133, 825	131, 000	163	150	− 2, 825	(*)	....	Mar. 1	29.2
J″	178	Arcadia Landing	109, 250	100, 250	151	132	− 9, 000	(*)	....	Mar. 2	29.4
J″	179	Just below Arcadia	120, 750	97, 500	105	118	−23, 250	(*)	....	Mar. 2	29.4
H″	181	1 mile below Arcadia	119, 250	113, 250	96	98	− 6, 000	(*)	....	Mar. 2	29.4
G″	182	1½ miles below Arcadia	115, 750	108, 500	87	89	− 7, 250	(*)	....	Mar. 2	29.4
F″	184	½ mile above Brown's Landing	124, 750	128, 125	102	90	+ 3, 375	(*)	....	Mar. 9	30.4
E″	186	Near Brown's Landing	152, 000	130, 000	160	177	−22, 000	(*)	....	Mar. 10	30.4
D″	188	½ mile below Brown's Landing	152, 250	147, 500	169	146	− 4, 750	(*)	....	Mar. 10	30.4
C″	S. L. 21	1 mile below Brown's Landing	125, 000	144, 000	135	137	+19, 000	(*)	....	Mar. 8	30.4
A″	194	1 mile above Dunboine Landing	118, 825	133, 000	105	104	+14, 175	(*)	....	Mar. 8	30.4
X′	A. 196	Ophelia Landing	126, 500	108, 325	97	90	−18, 175	(*)	....	Mar. 10	30.4
V′	S. L. 22	½ mile above Bayou Goula	132, 000	105, 570	133	115	−26, 430	(*)	....	Mar. 10	30.4
T′	200	½ mile below Bayou Goula	113, 500	112, 925	141	131	− 575	(*)	....	Mar. 13	30.5
S′	201	1 mile below Bayou Goula	112, 175	114, 250	131	138	+ 2, 075	(*)	....	Mar. 13	30.5
P′	S. L. 23	1½ miles above Belle Grove	148, 800	163, 750	158	156	+14, 950	(*)	....	Mar. 13	30.5
O′	206	½ mile above Belle Grove	112, 250	117, 625	105	109	+ 5, 375	(*)	....	Mar. 14	30.5
N′	207	Just above Belle Grove	124, 825	139, 500	110	116	+14, 675	(*)	....	Mar. 14	30.5
M′	209	Just below Belle Grove	119, 250	109, 150	97	97	−10, 100	(*)	....	Mar. 14	30.5
J′	213	Just above Hard Times	113, 675	93, 075	74	76	−20, 600	Apr. 9	30.0	Mar. 12	30.4
H′	216	1 mile below Hard Times	108, 500	97, 575	144	106	−10, 925	Apr. 5	30.0	Mar. 12	30.4
F′	218	½ mile above Southwood	109, 250	124, 500	97	126	+ 5, 250	Mar. 23	29.4	Mar. 12	30.4
E′	219	Just above Southwood	130, 250	145, 570	128	144	+15, 320	Mar. 22	29.4	Mar. 14	30.5
C′	223	1 mile below Southwood	116, 075	120, 150	115	131	+ 4, 075	Mar. 19	29.6	Mar. 15	30.6
A′	225	1½ miles below Southwood	118, 750	127, 250	92	103	+ 8, 500	Mar. 8	28.8	Mar. 15	30.6
X	228	1 mile below Woodstock	109, 750	110, 000	90	92	+ 250	Feb. 18	24.5	Mar. 15	30.7
V	230	Just above Ashland	110, 125	106, 125	78	79	− 4, 000	Feb. 12	24.4	Mar. 15	30.7
T	223	1 mile below Ashland	124, 375	127, 750	88	107	+ 3, 375	Feb. 10	24.4	Mar. 16	30.8
P	S. L. 27	½ mile above Ascension	120, 875	152, 125	104	110	+31, 250	Jan. 21	8.0	Mar. 16	30.8
O	239	Just above Ascension	119, 625	119, 000	99	105	− 625	Jan. 15	8.0	Mar. 16	30.8
M	241	½ mile below ascension	148, 575	161, 375	153	151	+12, 800	Jan. 6	13.9	Mar. 16	30.8
								1880.			
K	S. L. 28	1½ miles above Donaldsonville	119, 500	120, 250	118	115	+ 750	Dec. 28	19.5	Mar. 16	30.8
J	247	1 mile above Donaldsonville	120, 500	146, 000	108	112	+25, 500	Dec. 17	20.1	Mar. 16	30.8

* Soundings taken in April and May, dates not known. Baton Rouge gauge ranges between 29.9 and 29.8.

	Square feet.
Mean area of sections in 1881	122,836
Mean area of sections in 1883	123,593
Difference of means	757

Depths are referred to the plane of 1883.

Thirty-two sections which are identical with or come very near the sections of 1883 have been plotted and are shown on Plates 9, 10, and 11.

The sections of the Coast Survey and Geodetic Survey are copied from tracings (S. 48) on file in this office. The soundings there shown were reduced to the "average low water of the year" during which they were taken. The stage of the river when the soundings were made was but a little below the high water of 1881. A comparison of the sections is given in the above table, the area of the sections being measured below the lowest water surface, or that given by the United States Coast and Geodetic Survey sections. The sections were plotted and the areas measured with a planimeter by Assistant H. B. Wood.

Very respectfully, your obedient servant,

J. A. OCKERSON,
Assistant Engineer.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

APPENDIX H.

REPORT OF CAPTAIN CLINTON B. SEARS, CORPS OF ENGINEERS, UNITED STATES ARMY, EXECUTIVE OFFICER, DEPARTMENT OF CONSTRUCTION.

DEPARTMENT OF CONSTRUCTION,
Saint Louis, Mo., November 5, 1883.

COLONEL: In accordance with your circular letter of September 6, 1883, I have the honor to submit the following report of operations performed under my immediate supervision as executive officer, construction department, Mississippi River Commission, since the date of my last annual report, which was brought up to December 1, 1882.

My office has been fully employed during the past eleven months, in the construction of the floating plant, recommended by the Commission, and approved by the honorable the Secretary of War, in its distribution to the various works; in the charter of steamers; in the purchase and supply of stone, wire, coal, subsistence stores, and other material required on the several reaches; in the care of the fleet at Cairo, consisting of coal and floating plant not in use; in the repair of boats and barges, and in the management of the general service steamers.

The general system of purchase and supply was outlined in my last report, and need not be repeated here. This system, as there stated, has been continued. Special freight rates have been secured from commercial steamers and from the railroads, and shipments have been made by one or the other, as happened to be more favorable at the time, whenever the shipment has been so small as not to justify bringing one of our steamers to Saint Louis.

During the winter, when ice has closed the river down to Cairo, supplies have been shipped by rail to Cairo, and hence by our steamers. The steamers Mississippi and Etheridge have been kept in almost constant use towing our barges and other plant. In August the Etheridge, in bringing down a tow from Louisville, got aground at Flint Island bar, in the Ohio River, and was, after some difficulty, pulled off into deeper water above the bar. As there appeared to be no prospect of getting her down for some weeks, owing to low water, she was laid up at Louisville, under charge of watchmen, and her crew transferred to the steamer Jack Frost. Her tow was taken down by the Reindeer, a small light-draught boat, chartered temporarily for the purpose. October 16, the Etheridge reached Cairo in tow of the Minnetonka, and was put in commission immediately. August 7, the steamer John Dippold, a powerful boat belonging to the Mississippi Valley Transportation Company, was chartered for the general service at $50 per day, for two weeks, or longer, if necessary. She was kept in constant use until October 7, when she was turned in to the owners. Another large steamer, the Jack Frost, was chartered for the general service, September 15, 1883, at $50 per day, for such time as the Etheridge might be laid up. She was surrendered to her owners October 16, 1883, and the same day the new tow-boat, Minnetonka, was chartered for three months, at $60 a day, with the privilege of purchase at $45,000, less charter money paid. At present, therefore, we have in the general service, three steamers, two belonging to the United States and one chartered. During the ten months ending October 31, 1883, the Mississippi has moved 489 pieces over various distances, amounting to one piece moved 113,177 miles at a cost of 25.9 cents per mile. Her average daily expenses while doing this work have been $96.42; this includes fuel, pay, and subsistence of crew, and supplies and other running expenses, but does not include interest on her cost, nor the cost of repairs. She has also made several trips with the Commission or the construction committee, most of the running expenses of which have been paid by the secretary of the Commission, out of the appropriation for Mississippi River Commission.

The Etheridge during the eleven months has moved 377 pieces over various distances, amounting to one piece moved 104,861 miles, at a cost of 22 cents per mile. Her average daily expenses have been $68.84¼.

The Dippold, while under charter, moved 139 pieces over various distances, amounting to one piece moved 37,930 miles, at a cost of 35.3 cents per mile. Her daily expenses, including charter, averaged $212.76. She was in service 63 days. The Jack Frost, while under charter, moved 69 pieces, amounting to one piece moved 10,359 miles, at a cost of 49.4 cents per mile. Her daily expenses, including charter, averaged $165.12¼. She was under charter 31 days. These two steamers would have shown much better results, from an economical point of view, had circumstances permitted us to have worked them up to their full capacities. For reasons to be hereafter explained this was impracticable.

The Minnetonka has not been in service sufficiently long to enable me to report what will be a fair average as to her daily expenses. She was built for our work, and nothing has been left undone by her owners to make her an acceptable boat for that purpose. She is fully equipped in every respect for towing. My original arrangement with her owners was to charter her for six months, but owing to their delay in completing her, I cut this down to three months with the privilege of a renewal, if needed. Summing up the above, I find that our general-service steamers have averaged $135.78⅜, per day each, as to running expenses, and have moved 1,074 pieces various distances, or one piece 266,327 miles, at an average cost of 33.15 cents per mile. Estimating each piece at 100 tons (a low estimate) will make the cost per ton per mile one-third cent. Had we had this towing done by commercial steamers it would have cost about two-fifths cent per ton mile, and we would have been subjected to many vexatious and expensive delays.

My steamer captains have had great trouble in keeping efficient crews, especially during the sickly season. Government boats pay no hospital dues, and when men ship on them they forfeit their right to treatment and care at the marine hospitals, thus losing the benefit of dues previously paid when on commercial steamers. The past summer and fall seasons have been very unhealthy on the lower river, and several times our boats have been disabled for want of effective crews.

I would earnestly recommend that the Commission take some action towards securing, either through the Treasury Department or by Congress, some remedy for this evil. It seems to me but proper that men employed on United States civil vessels should have the right to hospital treatment. Practically this is at present denied them, and whether proper or not, it would certainly add to the efficiency of our steamer service if such medical aid could be given.

The chartered steamer Success, in use on Lake Providence Reach, was returned to her owners April 20, 1883, not having proved satisfactory.

January 1, 1883, I chartered the steamer Graham for six months, at $15 a day, for use on the Memphis Reach. July 1 this charter was extended three months with the privilege of six months. She is still under charter.

January 2, 1883, I bought the steamer Charlie De Pauw for $17,404, she having proved herself a valuable and efficient boat. She was kept in constant use on Lake Providence Reach until August, when she broke her shaft. She was sent to Saint Louis for a new shaft and a general overhauling. After being thoroughly repaired and partly repainted, her name was changed to the Vidalia, and she was returned to the Lake Providence Reach, where she is doing good work.

April 9, 1883, I chartered the steamer J. C. Fisher, for the Lake Providence Reach, at $17 per day for six months. Though her charter has expired we still retain her, and expect to have use for her until navigation closes.

June 1, 1883, I chartered the steamer Little Eagle No. 2, for use on the Plum Point Reach, for seven months, at $17.50 per day.

August 9, 1883, I chartered the steamer Pearl, for use on Lake Providence Reach, for three months, at $17.50 per day.

September 2, 1883, I chartered the steamer Little Andy Fulton, for use on Lake Providence Reach, at $30 a day for three months.

A tug and launch have been purchased for use at New Orleans, and another launch for use on Plum Point Reach.

The Commission has, therefore, the following steamers in commission:

Belonging to the United States:

Mississippi, Etheridge: Steam tow-boats for general service.
Pete Kirns, Itasca: Steam tow-boats in use at Plum Point.
Vidalia: Steam tow-boat in use at Lake Providence.
Mineola: Steam launch sunk at Plum Point.
Nellie: Steam launch in use at Lake Providence.
Titania: Steam launch in use at Plum Point.
Alaska: Steam launch in use at New Orleans.
Tilda: Steam tug in use at New Orleans.

Chartered:

Minnetonka: Steam tow-boat in general service.
Little Eagle No. 2: Steam tow-boat in use at Plum Point.
Graham: Steam tow-boat in use at Memphis.
J. C. Fisher: Steam tow-boat in use at Lake Providence.
Pearl: Steam tow-boat in use at Lake Providence.
Little Andy Fulton: Steam tow-boat in use at Lake Providence.

In all, eleven steamers, one tug, and four launches; six of the steamers being under charter.

The most difficult problem to solve has been the supply of stone to the works; and, so far, owing to a number of circumstances beyond my control, I have been unable to keep up the supply in a manner satisfactory to myself or to the district officers. The entire absence of suitable quarries between Cairo and Yazoo River, necessitates the stone being brought from up the Ohio River; or, from Chester, on the Mississippi River. At the time when stone is needed most, navigation is in the worst condition, due to low water or running ice in the Ohio, and low water or solid and running ice in the Mississippi.

Last winter the supply was entirely inadequate to the demand, owing to the danger to our barges from the running ice in the Ohio, and from the difficulty in loading barges at the quarries, due to bad weather and sleet.

During the summer and fall, navigation on the Ohio River has been so bad that I have taken off our boats, and have made arrangements with the contractor to receive and deliver our barges at Cairo, he using a small light-draught boat. It has also been dangerous to load our barges to their full capacities, owing to low water.

For several weeks I could not get barges up to the Ohio River quarries with even a small tow-boat. Early in the low-water season I arranged to get stone at Chester, Ill., but the loading facilities are limited. Another cause of failure in supply has been want of barges. This has arisen from two causes. The district officers of two districts have been pressed for barges, owing to the scattered condition of their parties and the long towage of brush, and have had to utilize whatever empty general-service barges were at hand. In this way, there resulted a large accumulation of general-service barges on the works, leaving the quarries without any for some two weeks.

Again, our barges, necessarily built out of green timber and sent down to a warm climate in the hottest season, soon began to need recalking, so that a number of barges have been unavailable, undergoing repair.

After getting a tow made up, low water in the Mississippi has made it both difficult and dangerous to get the tow down, and we have lost two barges and their loads at Tiptonville Bar, and one barge and its load at Old Hen, just above Hopefield. This condition of affairs has prevented the boats from being worked to their full capacities. During high water there is no trouble in getting stone loaded and towed down, but this is the time when there is least demand. In March, I began the storing of stone on the bank at Gold Dust, but had accumulated only some 3,000 yards when I had to take it all for use at Plum Point. In August I contracted for the delivery of 20,000 cubic yards on the bank at Arkansas City, for the use of the Lake Providence Reach. Up to October 31 there has been so delivered some 6,000 cubic yards. I have sent a party down to load this on barges.

The only way to insure a full supply of stone to the works during the busiest season is to begin in January of each year the accumulation of stone on the bank at two or more points, such as Gold Dust and Arkansas City; this to continue until the demand from the works increases so as to take all the quarries and towage service can supply. The stone so stored can then be taken, from time to time, as the direct supply fails during low water. This method, at best, is clumsy and expensive, but I see no other way less expensive and equally sure. This cannot be done, however, the coming season, unless an appropriation is made immediately available. We should have by August 1, 1884, at each of these places, some 20,000 yards at least. Since November 30, 1882, I have supplied to the works some 72,719 cubic yards of stone; 459 tons of galvanized steel wire, and several hundred tons of miscellaneous freight in the shape of provisions, rope, lumber, iron, and other supplies. Our contracts require us to take about 26,323 cubic yards of stone in addition to that already received. I submit herewith, marked A, a table showing the description, first cost, and distribution of the floating plant bought by me since November 30, 1882:

A synopsis is herewith submitted, viz:

1 Steam tow-boat	$17,404 00
1 Steam tug	5,000 00
1 Steam launch	3,000 00
7 Mattress-boats	40,360 00
4 Screen-boats	6,000 00
13 Quarter-boats	34,463 00
134 Barges	275,127 40
28 Pile-drivers	142,661 76
2 Machine-shop boats (balance)	9,871 25
1 Pumping-boat	1,500 00
6 Whitehall boats	339 00
94 skiffs	2,126 00
Outfit of plant	17,246 28
Miscellaneous (anchors, hoisting-engines, boilers, electric-light outfits, pump and derrick)	9,988 78
Rope	23,114 50
	588,201 97

Of this amount $142,983.68 was for plant now in use for the general service. An itemized statement of my expenditures from December 1, 1882, to October 31, 1883, accompanies this report, and is marked B.

The following is a classified statement of said expenditure:

SCHEDULE OF EXPENDITURES BY CAPTAIN CLINTON B. SEARS, EXECUTIVE OFFICER, CONSTRUCTION DEPARTMENT, MISSISSIPPI RIVER COMMISSION, ON ACCOUNT OF APPROPRIATION FOR IMPROVING MISSISSIPPI RIVER, FROM NOVEMBER 30, 1882, TO OCTOBER 31, 1883.

General service.

Office:		
Pay-roll	$8,469 83	
Furniture and office outfit	387 45	
Stationery	371 12	
Transportation and traveling expenses	1,400 85	
Ice and water	79 91	
Rent and repairs	679 70	
Gas and fuel	170 97	
Telegraphing	344 75	
Mileage	1,289 06	
Fuel for Captain Sears	160 48	
		$13,354 12
COAL FLEET.		
Material and supplies	$369 57	
Plant and outfit	336 93	
Transportation	174 84	
Labor	16 00	
Ice	7 59	
Care of public property	4,074 00	
Repairs	30 33	
		5,009 26
STONE DEPOT.		
Inspection and administration	$13 50	
Material and supplies	338 06	
Plant and outfit	1,453 90	
Transportation	14 35	
Labor	2,681 00	
Subsistence	54 00	
		4,554 81
STEAMER MISSISSIPPI.		
Office expenses	$46 51	
Material and supplies	2,133 99	
Fuel	33 21	
Plant and outfit	224 17	
Transportation and steamer expenses	12,832 85	
Repairs	1,517 42	
Labor	694 59	
Subsistence	5,061 36	
Care of public property	221 50	
		22,765 60

STEAMER EMMA ETHERIDGE.

Office expenses	$65 31	
Material and supplies	2,172 00	
Plant and outfit	1,433 50	
Transportation and steamer expenses	12,952 72	
Repairs	1,003 94	
Labor	498 20	
Subsistence	3,726 74	
Care of public property	207 99	
		$22,060 40

STEAMER JOHN DIPPOLD.

Office expenses	$6 40	
Material and supplies	1,199 20	
Fuel	3,665 60	
Repairs	14 35	
Transportation and steamer expenses	6,372 65	
Labor	40 75	
Subsistence	1,208 60	
		12,507 55

STEAMER JACK FROST.

Office expenses	$12 07	
Material and supplies	1,739 02	
Plant and outfit	19 25	
Fuel	1,131 19	
Transportation and steamer expenses	3,340 42	
Labor	10 00	
Subsistence	554 01	
		6,805 96

STEAMER REINDEER.

Material and supplies	$3 92	
Fuel	133 50	
Labor	8 00	
Transportation and steamer expenses	459 98	
Subsistence	79 05	
		684 45

STEAMER MINNETONKA.

Office expenses	$10 21	
Material and supplies	360 09	
Transportation and steamer expenses	866 34	
Fuel	427 60	
Labor	23 92	
Subsistence	302 58	
		1,990 74
Total account of general service		89,732 89

FOR NEW MADRID REACH.

Inspection and administration	$461 07	
Office expenses	3 00	
Plant and outfit	187,195 63	
Transportation	1,870 66	
Material and supplies	686 18	
Labor	20 00	
Repairs to plant	9 50	
Care of public property	18 50	
		190,264 54

FOR PLUM POINT REACH.

Inspection and administration	$1,383 42	
Office expenses	200 25	
Material and supplies	64,662 67	
Fuel	1,765 26	
Plant and outfit	88,596 73	
Transportation	5,674 28	
Repairs to plant	6,989 03	
Labor	401 49	
Subsistence	32,191 86	
Care of public property	622 00	
		202,486 99

FOR MEMPHIS REACH.

Inspection and administration	$1,250 16	
Office expenses	2 00	
Material and supplies	12,956 21	
Plant and outfit	121,791 54	
Transportation	5,712 24	
Repairs to plant	407 45	
Labor	115 50	
Subsistence	1,277 92	
Care of public property	260 65	
		$143,773 67

FOR LAKE PROVIDENCE REACH.

Inspection and administration	$1,934 49	
Office expenses	13 10	
Material and supplies	35,855 35	
Fuel	844 00	
Plant and outfit	144,152 84	
Transportation	13,064 08	
Repairs to plant	2,734 68	
Labor	432 54	
Subsistence	27,257 94	
Care of public property	586 46	
		226,875 48
Total account on improving Mississippi River		853,133 57

SCHEDULE OF EXPENDITURES ON ACCOUNT OF APPROPRIATION FOR IMPROVING HARBOR AT NEW ORLEANS, LA., FROM NOVEMBER 30, 1882, TO OCTOBER 31, 1883.

Inspection and administration	$299 67	
Office expenses	10 00	
Material and supplies	3,290 03	
Plant and outfit	24,460 97	
Transportation	677 50	
Repairs to plant	159 30	
Labor	168 97	
Subsistence	497 45	
Care of public property	6 00	
		29,569 89

SCHEDULE OF EXPENDITURES ON ACCOUNT OF APPROPRIATION FOR IMPROVING MOUTH OF RED RIVER, LOUISIANA, FROM NOVEMBER 30, 1882, TO OCTOBER 31, 1883.

Office expenses	$10 00	
Material and supplies	277 15	
Fuel	614 62	
Plant and outfit	4,524 00	
Labor	56 37	
Subsistence	910 60	
Transportation	26 00	
Care of public property	10 00	
		6,428 74

CLASSIFIED SUMMARY.

Expended for:		
Plant and outfit	$574,189 46	
Material and supplies	126,043 44	
Subsistence	73,122 11	
Transportation	65,439 76	
Repairs to plant	12,866 00	
Fuel and gas	8,946 43	
Office expenses (including pay-rolls)	8,848 68	
Care of public property	6,007 10	
Inspection and administration	5,342 31	
Labor	5,167 33	
Mileage	1,289 06	
Rent and repairs	679 70	
Furniture and office outfit	387 45	
Stationery	371 12	
Telegraphing	344 75	
Ice and water	87 50	
		889,132 20

GENERAL SUMMARY.

Improving harbor at New Orleans, La	$29,569 89	
For improving mouth of Red River, Louisiana	6,428 74	
		$35,998 63
For New Madrid Reach	190,264 54	
For New Madrid Reach, proportion of general service	4,605 84	
		194,870 38
For Plum Point Reach	202,486 99	
For Plum Point Reach, proportion of general service	38,144 57	
		240,631 56
For Memphis Reach	143,773 67	
For Memphis Reach, proportion of general service	8,837 91	
		152,611 58
For Lake Providence Reach	226,875 48	
For Lake Providence Reach, proportion of general service	38,144 57	
		265,020 05
		889,132 20

The above amount, $89,732.89, for the general service, has been divided up among the several allotments, as shown in the general summary. Whenever an expenditure has been specifically for any particular reach, it has, of course, been charged to that reach. There have been, however, large expenditures which it has been impossible, without complicating accounts very seriously, to definitely assign to any particular allotment. These I have divided among the several allotments in proportion to their respective amounts, duly considering the service each reach has received.

When towing for Red River and New Orleans has been done by the general service steamers, the necessary expense has been met by assigning sufficient of the vouchers of said steamers for payment by these appropriations. This method of dividing the general service expenses is inaccurate, clumsy, and unsatisfactory, and makes my accounts very complicated. I would recommend, therefore, that if another appropriation be given, a special allotment be made for the general service, with authority for me to draw on the several allotments for such amounts as cover specific expenditures for the corresponding reaches. I would further recommend that the officer in charge of the fourth district purchase all his own supplies except such as he may find convenient to have me buy and ship, as stone and coal. New Orleans is a better market for this district than Saint Louis.

I summit the following financial statement of all funds expended under the control of the Mississippi River Commission to November 1, 1883.

FINANCIAL STATEMENT.

(July 1, 1882, to October 31, 1883.)

NEW MADRID REACH.

	By Captain Sears.	By Captain Knight.	Total.
Drawn from Treasury	$207,000 00	$5,500 00	$212,500 00
Expended	204,572 16	4,498 95	209,071 11
Balances in hand, available November 1, 1883	2,427 84	1,001 05	3,428 89

All the allotment, viz, $212,500, has been drawn.

PLUM POINT REACH.

	By Captain Sears.	By Captain Knight.	Total.
Balances on hand from previous appropriation, fiscal year ending June 30, 1882	$10,232 11	$12,424 90	$22,657 01
Drawn from Treasury of current appropriation	314,000 00	635,000 00	949,000 00
Total to be accounted for	324,232 11	647,424 90	971,657 01
Expended	298,866 96	561,917 16	860,784 12
Balances in hand	25,365 15	85,507 74	110,872 89

Allotment from current appropriation	$1,000,000 00
Drawn from Treasury	949,000 00
Balance in Treasury	51,000 00
Balance in hands of disbursing officers	110,872 89
Available, November 1, 1883	160,872 89

MEMPHIS REACH AND HARBOR.

	By Captain Sears.	By Major Miller.	Total.
Drawn from Treasury, &c	$167,000 00	$125,000 00	$292,000 00
Expended	162,379 64	105,890 00	268,269 64
Balances in hand	4,620 36	19,110 00	23,730 36

Allotment from current appropriation	$325,000 00
Drawn	292,000 00
Balance in Treasury	33,000 00
Balance in hands of disbursing officers	23,730 36
Available November 1, 1883	56,730 36

SURVEY OF HELENA REACH.

Drawn by Major Miller	$8,000 00
Expended by Major Miller	7,511 29
Balance available November 1, 1883	488 71

All the allotment, viz, $8,000, has been drawn.

LAKE PROVIDENCE REACH.

	By Captain Sears.	By Captain Marshall.	Total.
Balances on hand from appropriation for fiscal year ending June 30, 1882	$10,232 11	$8,341 74	$18,573 85
Drawn from Treasury of current appropriation	354,000 00	459,000 00	813,000 00
Total to be accounted for	364,232 11	462,341 74	826,573 85
Expended	359,531 33	447,714 59	807,245 92
Balances in hand	4,700 78	14,627 15	19,327 93

Allotment from current appropriation	$950,000 00
Drawn	813,000 00
Balance in Treasury	137,000 00
Balance in hands of disbursing officers	19,327 93
Available November 1, 1883	156,327 93

VICKSBURG HARBOR.

Drawn by Captain Marshall	$50,000 00
Expended by Captain Marshall	44,522 40
Balance in hand	5,477 60
Allotment from current appropriation	100,000 00
Drawn	50,000 00
Balance in Treasury	50,000 00
Balance in hand	5,477 60
Available November 1, 1883	55,477 60

NEW ORLEANS HARBOR.

	By Captain Sears.	By Major Stickney.	Total.
Balance in Treasury July 1, 1882, from previous appropriation.	....	....	$144,525 90
Balances in hand July 1, 1882	....	$3,267 91	3,267 91
Total to be accounted for	....	3,267 91	147,793 81
Drawn from Treasury	$38,000 00	3,267 91	41,267 91
Expended	29,569 89	8,845 01	38,414 90
Balances in hand	8,430 11	—5,577 10	2,853 01

Available July 1, 1882	$147,793 81
Drawn	41,267 91
Balance in Treasury	106,525 90
Balance in hands of disbursing officers	2,853 01
Available November 1, 1883	109,378 91

SAINT FRANCIS FRONT, FIRST DISTRICT.

Drawn by Captain Knight	$5,000 00
Expended by Captain Knight	3,312 91
Balance available November 1, 1883	1,687 09

All the allotment, viz, $5,000, has been drawn.

SAINT FRANCIS FRONT, SECOND DISTRICT.

Drawn by Major Miller	$4,000 00
Expended by Major Miller	3,212 93
Balance available November 1, 1883	787 07

All the allotment, viz, $4,000, has been drawn.

MOUTH OF RED RIVER.

	By Captain Miller.	By Captain Sears.	By Major Stickney.	Total.
Drawn from the Treasury from previous appropriations.	$15,812 40	$7,000 00	$15,000 00	$37,812 40
Expended	7,658 46	6,428 74	37,883 46	51,970 66
Balances in hand	*8,153 94	571 26	—22,883 46	—14,158 26

*Transferred to Major Stickney, September 30, 1882.

Available June 30, 1882	$90,812 40
Drawn	37,812 40
Balance in Treasury	53,000 00
Balance in hands of disbursing officers	—14,158 26
Available November 1, 1883	38,841 74

NATCHEZ AND VIDALIA.

	By Captain Miller.	By Major Stickney.	Total.
Available June 30, 1882, from former appropriations	$8,252 04		$8,252 04
Expended	722 95	$2,197 67	2,920 62
Balance available November 1, 1883	*7,529 09	—2,197 67	5,331 42

* Transferred to Major Stickney, September 9, 1882.

OBSERVATIONS AT CARROLLTON, LA.

The allotment of $3,000 from the appropriation for improving Mississippi River has been drawn and expended by Major Stickney. The observations are now being carried on with an allotment from the appropriation for Mississippi River Commission.

SURVEY OF UNLEVEED FRONTS IN THIRD DISTRICT.

Drawn by Captain Marshall	$1,000 00
Expended by Captain Marshall	496 96
Balance available November 1, 1883	503 04

All the allotment, viz: $1,000, has been drawn.

SURVEY OF UNLEVEED FRONTS IN FOURTH DISTRICT.

Allotment	$1,000 00

None of which has been drawn or expended.

SURVEY OF CUBITT'S GAP.

Drawn by Major Stickney	$300 00
Expended by Major Stickney	137 14
Balance available November 1, 1883	162 86

All the allotment, viz: $300, has been drawn.

DELTA POINT, LOUISIANA.

Balance from another appropriation	$25,770 13
Allotment from appropriation for improving Mississippi River	50,000 00
Available June 30, 1882	75,770 13
Expended by Captain Marshall	75,762 49
Balance on hand	7 64

This work is finished.

CHOCTAW BEND SURVEY.

Drawn by Captain Marshall	$2,700 00
Expended by Captain Marshall	2,679 86
Balance in hand	20 14
Allotment from current appropriation	4,000 00
Drawn	2,700 00
Balance in Treasury	1,300 00
Balance in hand	20 14
Available for transfer to other works	1,320 14

This survey has been completed.

BONNET CARRE CREVASSE.

All of the allotment, viz: $15,000, has been drawn and expended by Major Stickney.

LEVEES, SECOND DISTRICT.

Yazoo Front.

Drawn by Major Miller	$80,950 00
Expended by Major Miller	79,832 25
Balance available November 1, 1883	1,117 75

All the allotment, viz: $80,950, has been drawn.

THIRD DISTRICT.

Tensas Front.

Drawn by Captain Marshall	$328,840 00
Expended by Captain Marshall	$291,156 49
Balance in hand	37,683 51
Allotment from current appropriation	348,840 00
Drawn	328,840 00
Balance in Treasury	20,000 00
Balance in hand	37,683 51
Available November 1, 1883	57,683 51

Yazoo Front.

Drawn by Captain Marshall	$334,050 00
Expended by Captain Marshall	313,836 32
Balance available November 1, 1883	20,213 68

All the allotment, viz, $334,050 has been drawn.

FOURTH DISTRICT.

Atchafalaya Front.

Drawn by Major Stickney	$100,000 00
Expended by Major Stickney	102,947 22
Balance in hand	— 2,947 22
Allotment	110,000 00
Drawn	100,000 00
Balance in Treasury	10,000 00
Balance in hand	— 2,947 22
Available November 1, 1883	7,052 78

Tensas Front.

Drawn by Major Stickney	$426,160 00
Expended by Major Stickney	251,630 81
Balance available November 1, 1883	174,529 19

All the allotment, viz, $426,160, has been drawn.

Total levee allotments, including Bonnet Carre Crevasse	1,315,000 00
Drawn	1,285,000 00
Balance in Treasury	30,000 00
Balance in hands of disbursing officers	230,596 91
Available November 1, 1883	260,596 91

SUMMARY.

Total allotments	$3,978,800 00
Unallotted and in Treasury	144,200 00
Unallotted and in hands of Captain Sears, from sale of fuel to himself.	126 00
Total appropriation	4,123,126 00
Balances from last appropriation	36,230 86
Balances from other appropriations	272,628 38
Total	4,431,985 24
Accounted for as follows:	
In U. S. Treasury, not drawn	607,025 90
Expended	3,433,716 04
In hands of disbursing officers	391,243 30
Total	4,431,985 24
Total available November 1, 1883, for works carried on under the Mississippi River Commission	998,269 20

The greater portion of this available balance will be exhausted by January 1, 1884.

The large amount of public property to be taken care of, and the uncertainty concerning the time when another appropriation will be made, makes it desirable to reserve sufficient funds to amply provide for such care of property. I would, therefore, recommend to the Commission that the work on the several reaches be brought to a close at an early date, and the forces be reduced to the lowest point compatible with the proper protection of the works, the care of public property, and the settlement of accounts.

All of which is respectfully submitted.

CLINTON B. SEARS,
Captain, Engineers, U. S. A.,
Executive Officer, Construction Dep't, M. R. C.

Lieut. Col. C. B. COMSTOCK,
Corps of Engineers, U. S. A.,
President Mississippi River Commission.

List of plant purchased by Capt. C. B. Sears, Corps of Engineers, U. S. A., from December 1, 1882 to November 1, 1883.

Description.	No.	Average first cost of each.	Total cost.	Allotment or appropriation from which paid.	Where used.
Steam tow-boat	1	$17,404 00	$17,404 00	Lake Providence	Lake Providence Reach.
Steam tug	1	5,000 00	5,000 00	New Orleans Harbor	New Orleans Harbor.
Steam launch	1	3,000 00	3,000 00	do	Do.
Mattress boats	2	6,900 00	13,800 00	Lake Providence	Lake Providence Reach.
Do	2	6,000 00	12,000 00	Memphis	Memphis Reach.
Do	3	4,853 33⅓	14,560 00	Plum Point	Plum Point Reach.
Screen boats	4	1,500 00	6,000 00	Memphis	Memphis Reach.
Quarter boats	4	4,000 00	16,000 00	Lake Providence	Lake Providence Reach.
Do	2	1,803 00	3,606 00	Mouth of Red River	Bayou Plaq., and mouth of Red River.
Do	4	2,234 25	8,937 00	Memphis	Memphis Reach.
Do	3	1,973 33⅓	5,920 00	Plum Point	Plum Point Reach.
Barges	34	2,536 11 2/17	86,228 00	Plum Point and Lake Providence	General service.
Do	2	1,960 00	3,920 00	Lake Providence	General service, towing.
Do	22	1,831 81 9/11	40,300 00	New Madrid	General service.
Do	18	1,873 61 1/9	33,725 00	do	Plum Point Reach.
Do	20	2,125 00	42,500 00	Lake Providence	Lake Providence Reach.
Do	1	2,000 00	2,000 00	Memphis	Plum Point Reach.
Do	4	2,000 00	8,000 00	do	Lake Providence Reach.
Do	21	1,994 28 4/7	41,880 00	do	Memphis Reach.
Do	12	1,381 20	16,574 40	New Orleans Harbor	New Orleans Harbor.
Pile-drivers	5	5,325 88	26,629 40	New Madrid	Plum Point Reach.
Do	5	5,325 88	26,629 40	do	Lake Providence Reach.
Do	10	5,325 88	53,258 80	do	One in use; quarter boat for S. D. of G. S.; 9 laid up at Cairo.
Do	8	4,518 01	36,144 08	Memphis	Laid up at Cairo.
Machine-shop boat (superstructure and machinery).	1	4,750 00	4,750 00	New Madrid	Plum Point Reach.
Machine-shop boat (superstructure and machinery, and tool outfit).	1	5,121 25	5,121 25	Memphis	Memphis Reach.
Pumping-boat	1	1,500 00	1,500 00	Plum Point, Memphis, and Lake Providence.	General service (fleet at Cairo).
Whitehall boats	6	56 50	339 00	Plum Point	Plum Point Reach.
Skiffs	34	24 60 5/17	836 50	do	Do.
Do	30	22 00	660 00	Memphis	Memphis Reach.
Do	2	17 00	34 00	Mouth of Red River	Bayou Plaq., and mouth of Red River.
Do	2	23 00	46 00	New Orleans Harbor	New Orleans Harbor.
Do	23	22 02	506 50	Lake Providence	Lake Providence Reach.
Do	3	14 33⅓	43 00	Plum Point, Memphis, and Lake Providence.	General Service (Stone Dep. and Strs.)
Miscellaneous small plant for use on floating property.					
Outfit			873 78	Mouth of Red River	Bayou Plaq., and mouth of Red River.
Do			3,920 10	Lake Providence	Lake Providence Reach.
Do			227 45	New Madrid	In store at Cairo.
Do			12,224 95	Plum Point	Plum Point Reach.

Anchors			1,630 48	New Madrid	Plum Point, and in store at Cairo.
Do			195 75	Plum Point	Plum Point Reach.
Do			365 58	Lake Providence	Lake Providence Reach.
Do			10 22	Mouth of Red River	Bayou Plaq., and mouth of Red River.
Hoisting engines	1	807 00	807 00	Memphis, Plum Point, and Lake Providence.	General service, Stone Depot.
Do	1	1,535 00	1,535 00	Plum Point	Plum Point Reach.
Vertical boilers	2	202 00	404 00	do	Do.
Electric-light outfits	2		765 90	Plum Point, Memphis, and Lake Providence.	General service steamers.
Do	3		2,559 85	Plum Point	Plum Point Reach.
Do	1	938 50	938 50	Lake Providence	Lake Providence Reach.
Pumps	7	39 93	279 50	Plum Point, Memphis, and Lake Providence.	General service.
Do			172 00	Plum Point	Plum Point Reach.
Derrick			325 00	Plum Point, Memphis, and Lake Providence.	General service, Stone Depot.
Rope			3,489 40	do	General service.
Do			14,840 24	Plum Point	Plum Point.
Do			664 26	Memphis	Memphis Reach.
Do			4,111 60	Lake Providence	Lake Providence Reach.
Total			588,201 97		

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive.

[Act of August 2, 1882.]

By CLINTON B. SEARS, captain of Engineers, U. S. A., executive officer, Mississippi River Commission.

GENERAL SERVICE.

OFFICE.

Date.	Voucher number.	For what expended.	Pay-roll.	Furniture and outfit.	Stationery.	Transportation and traveling expenses.	Ice and water.	Rent and repairs.	Gas and fuel.	Telegrams.	Mileage.	Fuel for Capt. C. B. Sears.	Total.
1882.													
Dec. 7	48	Pens			$1 02								
1	203	Rent						$60 00					
5	229	Gas							$3 75				
4	238	Ice					$17 46						
	240	Furniture		$112 50									
30	241	Pay-roll	$611 00			$200 00		5 00					
	251	Stationery			25 80								
	252	Outfit		41 60									
12	255	Mileage									$109 36		
15	263	Traveling expenses				35 80							
18	269	......do				11 50							
25	310	Mileage									170 56		
27	315	Fuel										$23 60	
20	316	Street-car tickets				10 00							
29	320	Telegrams								$124 80			
1883.													
Feb. 5	15	......do								34 01			
Jan. 2	23	Rent						60 00					
Feb. 5	48	Outfit (lamp and shade)		8 50									
Jan. 17	58	Paper and envelopes			28 45								
16	59	Oil							10 14				
15	62	Street-car tickets				10 00							
Feb. 1	69	Telegrams								1 86			
Jan. 6	70	Gas							6 25				
31	75	Water					7 50						
12	80	Mileage									51 66		
27	133	Fuel										23 60	

Feb.	3	188	Rubber stamps		3 50									
Jan.	31	156	Pay-roll (January)	743 00			200 00							
	3	157	Pens			85								
	29	161	Fuel							71 90				
Feb.	1	164	Rent						60 00					
	6	185	Fuel (gas)							7 14				
	1	186	Supplies			3 75								
	12	189	......do		2 01									
	1	190	Electrotype			2 50								
	28	201	Pay-roll (February)	786 88			200 00							
	7	210	Mileage									28 68		
	2	216	Rubber-stamps			4 00								
	15	219	Street-car tickets				10 00							
	17	223	Stationery			80 61								
	27	246	Mileage									51 68		
	28	259	Coal							28 60				
Mar.	2	278	Water-filter		16 50									
	3	284	Telegrams								1 14			
	3	285	......do								21 08			
	5	290	Street-car tickets				10 00							
	5	296	Gas							5 24				
	1	297	Rent						60 00					
	14	327	Stationery			2 00								
	31	336	Pay-roll (March)	861 00			200 00							
	3	337	Coal							3 50				
	14	342	Mileage									67 68		
	24	349	Coal										28 60	
	24	350	Blanks			11 00								
	24	351	Supplies			1 80								
	24	352	Outfit			23 85								
	24	354	Supplies			17 40								
	24	356	Books			5 50								
	26	365	Street-car tickets				10 00							
	29	373	Fuel							28 12				
Apr.	2	2	Awnings		67 00									
	3	7	Rent						60 00					
	6	8	Parchment			5 50								
	6	22	Telegrams								80			
	3	71	Mileage									102 00		
	9	72	Directory			5 00								
	6	90	Telegrams								16 45			
	7	91	Coal							8 00				
	6	103	Gas							8 38				
	26	134	Coal										28 60	
	28	141	Paper			5 25								
	28	144	Stationery			22 20								
	27	145	Street-car tickets				10 00							
	30	157	Labor		12 00									
	30	158	Pay-roll (April)	829 50			200 00							
May	1	167	Rent						60 00					
	2	168	Calagraph		90 00									

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, *to October* 31, 1883, *both inclusive*—Continued.

OFFICE—Continued.

Date.	Voucher number.	For what expended.	Pay-roll.	Furniture and outfit.	Stationery.	Transportation and traveling expenses.	Ice and water.	Rent and repairs.	Gas and fuel.	Telegrams.	Mileage.	Fuel for Capt. C. B. Sears.	Total.
1883.													
May 3	170	Microscope		$2 50									
9	175	Mileage									$51 20		
7	177	Gas							$1 19				
7	178	Telegrams								$1 14			
11	181	......do								28 00			
11	192	Book			$6 50								
11	210	Envelopes			2 50								
31	213	Pay-roll (May)	$787 00			$200 00							
16	238	Mileage									24 00		
22	252	Sprinkling street					$6 00						
25	264	Coal										$4 72	
25	267	Street-car tickets				10 00							
28	280	Stationery			82 15								
June 1	296	Rent						$60 00					
2	342	Mileage									76 72		
5	343	Telegrams								1 77			
5	344	......do								15 00			
June 6	359	Gas							95				
14	373	Mileage									101 92		
18	376	Supplies		1 33									
18	380	Stationery			1 90								
23	399	Picture-frames		8 26									
23	402	Mileage									51 20		
25	405	Fuel										4 72	
7	406	Sprinkling street					6 00						
7	407	Barge bulletin		7 25									
30	416	Pay-roll (June)	791 50										
1	417	Mucilage			2 00								
1	418	Labor		3 50									
1	419	Arrows		4 00									
1	420	Wheels		1 25									
July 3	12	Rent						60 00					
6	43	Gas							48				
9	44	Telegrams								9 24			

	16	67	do								50			
	19	72	Mileage									18 28		
	27	82	Sprinkling street					6 00						
	31	94	Pay-roll (July)	812 00										
	2	95	Telegrams								25			
	2	96	Street-car tickets				10 00							
	30	111	Coal										4 72	
	25	121	Mileage									24 00		
Aug.	1	127	Rent						60 00					
	1	128	Water					7 50						
	4	134	Stationery			2 96								
	8	146	Telegrams								20 17			
	9	149	Ice					11 45						
	15	188	Frames		2 50									
	18	189	Mileage									51 20		
	17	202	Stationery			49 00								
	29	230	Sprinkling street					6 00						
	29	236	Coal										4 72	
	27	244	Mileage									56 88		
	29	245	do									51 20		
	31	253	Pay-roll (August)	753 50										
	4	258	Traveling expenses				7 50							
	4	261	Street-car tickets				10 00							
	30	268	Soap			1 15								
Sept.	3	280	Stationery		8 75									
	1	298	Rent						60 00					
	1	311	Mileage									24 00		
	8	328	Telegrams								30 69			
	13	349	Stationery			6 00								
	17	372	Mileage									51 20		
	18	375	Rubber stamps		3 50									
	21	394	Stationery			5 80								
	22	400	Sprinkling					6 00						
	25	409	Stationery			6 30								
	8	414	Repairs						4 50					
	8	415	Telegrams								5 38			
	8	416	Traveling expenses				10 80							
	8	417	Telegrams								68			
	29	419	Pay-roll (September)	746 00										
	26	420	Coal										23 60	
	28	422	Street-car tickets				10 00							
	30	431	Mileage									24 00		
Oct.	1	3	Rent						60 00					
	7	10	Mileage									73 28		
	8	20	Gas							2 38				
	22	42	Supplies			9 85								
	20	62	Stationery			10 38								
	20	66	Gas-fixtures						35					
	20	70	Tape		4 50									
	24	79	Telegrams								2 25			
	24	80	Mileage									38 40		

Itemized statement of expenditures for improving the Mississippi River from December 1, 1882, *to October* 31, 1883, *both inclusive*—Continued.

OFFICE—Continued.

Date.	Voucher number.	For what expended.	Pay-roll.	Furniture and outfit.	Stationery.	Transportation and traveling expenses.	Ice and water.	Rent and repairs.	Gas and fuel.	Telegrams.	Mileage.	Fuel for Capt. C. B. Sears.	Total.
1883.													
Oct. 29	86	Pay-roll	$748 50										
2	87	Traveling expenses				$10 50							
2	89	do				11 80							
2	90	do				12 95							
24	92	Sprinkling street					$6 00						
22	102	Telegrams								$80 54			
29	114	Fuel										$28 60	
		Total	8,469 88	$890 95	$377 47	1,400 85	79 91	$669 85	$170 97	344 75	$1,289 12	100 48	$18,854 12

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

COAL FLEET.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1882.													
Dec. —	213	Supplies			$40 00								
....	226	Grate bars			13 32								
1	231	Supplies			10 78								
14	260	Services, Reindeer										$150 00	
30	290	......do										155 00	
30	319	Pay-roll, December										439 25	
1883.													
Jan. 17	44	Labor and material			56 60			$15 75					
17	50	Brace and bitts			2 31								
25	104	Pumps and pipe			77 12								
31	135	Services, Reindeer										155 00	
Feb. 5	Part, 165	Labor and material			19 44								
Jan. 31	166	Pay-roll, January										405 00	
17	191	Services, tug										50 00	
Feb. 28	202	Pay-roll, February										341 50	
28	248	Pumps			12 90								
Mar. 1	261	Services, tug										140 00	
13	323	Supplies			4 53								
31	379	Services, tug										155 00	
31	382	Pay-roll, March										361 00	
Apr. 6	11	Grate bars							$14 53				
19	108	Steel figures					$22 50						
30	146	Tools			10 29			1 00					
30	166	Pay-roll, April										355 00	
May 5	173	Labor and repairs							3 00				
11	223	Services of tug						150 00					
12	227	Towage						14 37					
18	241	Pumps and fittings					314 43						
31	297	Pay-roll, May										301 00	
June 4	315	Transportation						6 35					
5	323	Hose			53 90								
30	421	Pay-roll, June										235 00	
July 12	45	Material			35 25								

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

COAL FLEET—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
July 3	55	Office expenses		$0 25				$0 75					
3	56	Subsistence									$0 87		
31	122	Pay-roll, July										$247 00	
Aug. 2	151	Subsistence									1 87		
2	152	Repairs							$0 75				
2	153	Care of public property										10 00	
16	192	Material and expense			$5 18			50					
16	196	....do			26 00			1 00					
31	277	Pay-roll, August										238 00	
Sept. 3	279	Repairs and transportation						87	12 00				
4	295	Labor								$10 00			
18	377	Material			1 95								
Oct. 2	2	Pay-roll										221 50	
9	7	Labor								104 75			
22	51	Ice									4 85		
		Total		25	369 57		$336 93	190 59	30 33	114 75	7 59	3,959 25	$5,009 26

STONE DEPOT.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
May 11	190	Rope			76 61								
11	211	Outfit					305 00						
11	215	Blocks					20 00						
14	232	Hoisting engine					307 00						
Apr. 2	247	Traveling expenses	5 00										
May 5	248	......do	8 50										
June 4	306	Skiff					16 00						
May 5	311	Transportation						1 10					
June 5	318	Rope			155 05								
May 31	350	Pay-roll, May										117 33	

	22	351	Traveling expenses						$6 25					
	22	352	......do						5 00					
	22	353	Labor								$5 00			
June	7	429	Meals									$12 50		
	30	430	Pay-roll, June										$487 00	
July	5	15	Supplies			$13 24		$12 65						
	6	25	Derrick guys					175 00						
	31	115	Pay-roll, July										497 00	
Aug.	13	177	Supplies			85 58								
	29	240	Medicine						1 00			16 50		
Sept.	3	325	Pay-roll, August										550 00	
	7	326	..... do										82 00	
	25	407	Supplies			7 58			1 00					
	30	450	Pay-roll, September										563 00	
Oct.	22	51	Ice									25 00		
	26	103	Wheelbarrows					87 50						
	29	110	......do					80 00						
....		......	Barrel					75						
....		......	Pay-roll										429 67	
			Total	$18 50		338 06		1,453 90	14 35		5 00	54 00	2,676 00	$4,554 81

STEAMER MISSISSIPPI.

1882.														
Dec.	—	211	Gong-bell						12 60					
....		239	Towage						12 00					
	6	244	Lumber			53 98								
	7	246	Elbows						1 80					
....		247	Labor and material						8 00		2 25			
	7	248	Repairs			6 15								
....		249	Labor and material			54 70					49 00			
....		251	Outfit		$4 00									
	4	259	Medicine						5 65					
	11	264	Stores and supplies			2 45						29 09		
	20	286	Material for repairs			1 15								
	20	287	Door liners						28 44					
	23	294	Stores and supplies			8 40						201 11		
1883.														
Jan.	9	32	Coal				$33 21							
	17	54	Labor or repairs						34 72					
	17	64	Stencils					7 75						
	25	74	Stores and supplies			60						187 01		
	26	76	......do			16 20						12 25		
Feb.	7	79	Subsistence									89 75		
	2	81	Lumber			6 81								
1882.														
Dec.	7	83	Supplies			2 00						86 93		
	7	84	......do			54 35								

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

STEAMER MISSISSIPPI—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1882.													
Dec. 7	85	Labor								$3 60			
7	86	Gauge cocks						$3 00					
7	87	Milk									$2 00		
7	88	Sponge						1 00					
31	89	Pay-roll, December						1,041 84			100 00	$40 50	
1883.													
Jan. 25	108	Transportation						1 50					
30	130	Supplies			$67 47						189 90		
30	131	......do			4 01						41 36		
30	137	Paper			8 08								
31	139	Pay-roll, January						1,324 85			158 00	45 00	
8	158	Varnish			1 50								
8	169	Supplies									86 20		
8	170	......do									14 80		
8	171	Labor and material			7 00					8 00			
8	172	Labor								12 50			
8	173	......do								25 00			
Feb. 16	221	Supplies			9 35								
17	223	Stationery			4 65								
16	225	Outfit					$23 65						
19	229	Labor and material			26 86			196 60					
20	230	Guide and insulater			1 40								
22	239	Supplies			58 68			1 00					
27	252	Labor and material			80 40					29 60			
28	254	Subsistence									57 84		
8	255	......do									14 80		
8	256	Labor								12 50			
8	257	Subsistence									14 80		
28	258	Pay-roll (February)						1,278 48			145 00	55 00	
Mar. 1	264	Supplies			2 00						72 89		
2	273	Labor and material						80 10					
3	282	Blanks		$14 50									
5	288	Subsistence						2 40			67 61		
8	303	Rope			183 45								

	8	807	Subsistence									58 90		
	9	817	Lumber			42 20								
	9	820	Supplies			88 81					8 50	2 75		
	12	821	Labor and material						61 00					
	13	825	Frames		2 70									
	14	829	Supplies			68 20			10 15			220 01		
	31	830	Pay-roll (March)						587 83			90 00	60 00	
	7	831	Labor								10 00			
	7	832	......do								11 50			
	7	833	......do								10 00			
	7	834	......do								21 50			
	7	835	Eggs									6 90		
	8	838	Transportation						8 00					
	24	839	Subsistence						1 50			34 82		
	24	840	Labor and material			1 40					8 00			
	24	841	Labor								16 00			
	24	843	Admeasurement						19 50					
	24	855	Stationery		12 75									
Apr.	2	3	Subsistence									68 85		
	2	4	Labor and repairs							$15 00				
	6	19	Grate-bars							34 83				
	7	23	Subsistence									14 00		
	7	29	Steam-fittings			5 02								
	9	34	Labor, materials, and repairs							42 67				
	11	48	......do			80 15					165 50			
	10	54	Services						40 00					
	12	53	Meat									50 85		
	12	59	Supplies			19 66								
	13	66	Subsistence									153 78		
	16	85	......do									62 42		
	23	125	Supplies					5 00						
	23	130	......do						5 65			106 48		
	26	133	Outfit					42 94	1 00					
	30	147	Services						17 50					
Mar.	31	159	Pay-roll (March)						175 53			170 00	45 00	
Apr.	2	160	Meat									18 86		
	2	161	Labor								32 60			
	2	162	Meat									7 75		
	2	163	Labor								30 00			
	30	164	Pay-roll (April)						1,256 51			175 00	45 00	
May	5	172	Labor								26 62			
	5	176	Transportation						10 00					
	11	182	Supplies			123 83								
	11	183	......do			14 75					4 50	28 51		
	11	185	......do			17 80								
	11	186	......do			8 90						24 10		
	11	189	......do			101 10								
	11	193	Press-book			8 15								
	11	205	Supplies									48 84		
	11	206	Outfit					15 25		12 85				
	11	207	Meat and ice									61 16		
	11	208	Tarpaulins					66 00						

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

STEAMER MISSISSIPPI—Continued.

Date.		Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.														
May	11	209	Lumber							$52 05				
	11	212	Supplies			$22 53						$92 76		
	11	226	Chains					$46 08						
	16	235	Labor and material							110 10				
	23	255	Supplies			36 63		12 70	$1 20					
	24	258	Iron							17 50				
	26	266	Labor							20 00				
	28	274	Material			80								
June	2	299	Subsistence									53 05		
	2	300	do									49 90		
May	31	309	Pay-roll (May)						1,237 82			149 67	$45 00	
	5	310	Subsistence									12 60		
	5	312	Labor								$31 40			
	5	313	do								26 75			
June	5	326	Envelopes		$1 50									
	7	331	Subsistence									80 68		
	8	337	Medical supplies			4 01								
	8	338	Castings and bolts			67 65			1 00					
	30	354	Pay-roll (part June)						415 15			53 83	18 50	
May	29	355	Labor								10 30			
	29	356	do								37 25			
June	18	377	Shovels			9 70								
	18	378	Flange and sleeve							9 50				
	21	391	Locks and bolts			1 00								
	30	411	Pay-roll (part June)						407 34			62 00	21 00	
July	3	7	Stores and supplies			12 15						101 03		
	5	17	Supplies			186 70								
	5	21	Towage						15 00					
	5	23	Labor and material							307 20				
	6	26	Lumber							19 98				
	6	28	Frames			8 85								
	7	32	Paint			41 00								
	9	39	Supplies			7 05				61 60				
	12	47	Subsistence						4 20			152 04		

	12	48	Labor and material							15 00				
	13	51	Subsistence									64 08		
	23	75	Labor and material							347 10				
	23	78	Subsistence									31 30		
	25	87	Labor								8 00			
	27	89	Supplies			30 58								
	28	92	Labor and material			1 60					4 50			
	2	112	Labor								29 05			
	2	113	......do								31 62			
	31	114	Pay-roll (July)						1,352 84			115 00		
Aug.	2	125	Kevel							2 50				
	3	130	Outfit			3 00								
	3	131	Labor and material			6 60					6 00			
	4	133	Paper		2 10									
	17	211	Rings							3 00				
	27	216	Supplies and subsistence									51 80		
	29	237	......do									199 95		
	27	243	Transportation						12 00					
	4	256	......do						50					
	30	267	Subsistence									66 07		
	30	278	Frames			3 75								
	30	278	Subsistence									80 50		
Sept.	3	283	Stores and supplies			37 68						1 85		
	3	293	......do			6 25						51 42		
	8	319	Lamps			16 70								
	8	322	Stores and supplies			18 01						74 28		
	4	323	Pay-roll						1,581 28					
	10	332	Subsistence									61 10		
	10	333	Lumber							10 00				
	10	334	Supplies							2 25				
	10	335	Subsistence									12 74		
	10	336	Stores and supplies			3 25						28 90		
	13	351	Oil-can			6 50								
	17	366	Stationery		5 00									
	17	374	Subsistence									42 00		
	4	388	......do									26 43		
	4	389	Labor								26 15			
	4	390	Labor and material							20 75				
	22	399	Fire-hooks			4 86								
	30	444	Machinery repairs							55 88				
	30	446	Subsistence									63 70		
	30	471	Pay-roll (September)						1,615 37					
Oct.	1	1	Repairs							27 00				
	2	4	Paper		3 96									
	9	9	Subsistence									22 30		
	10	17	......do									25 60		
	26	26	Services						8 75					
	22	28	Subsistence						5 60			175 22		
	22	38	Supplies			434 78			7 85			16 00		
	20	44	Labor								4 50			
	22	59	Supplies						1 40			58 80		
	20	63	Grate-bars							3 15				

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, *to October* 31, 1883, *both inclusive*—Continued.

STEAMER EMMA ETHERIDGE—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
Mar. 9	316	Meat									$7 00		
10	319	Transportation						$7 60					
12	322	Lumber			$11 27								
13	Part, 325	Frames		$2 70									
24	348	Outfit			81 78								
24	Part, 355	Stationery		12 75									
26	359	Labor						59 45					
24	360	Labor and material			263 00			314 00					
31	362	Pay-roll (March)						248 52			33 84	$9 33	
31	363	......do						507 50					
31	364	Subsistence									9 40		
28	368	Lamps					$7 25	60					
31	375	Labor and material			187 94			218 85					
Apr. 2	1	Outfit					450 00						
6	12	......do					12 75						
6	14	Repairs							$51 99				
6	15	Carpet					9 60						
6	18	Subsistence									30 05		
6	20	Grate-bars							27 50				
7	24	Subsistence									56 85		
7	26	Tarpaulins					26 50						
7	27	Labor							65 63				
7	28	Subsistence									84 15		
7	30	Stationery		6 20									
9	38	Labor and material			11 92					$5 25			
10	40	Subsistence									6 50		
10	42	Asbestos covering							53 10				
11	49	Electric outfit					765 90						
10	53	Labor and material							26 05				
12	60	Labor and supplies			290 04					5 50			
13	63	Supplies			195 71								
13	64	Labor and material								109 04			

	13	67	Stores and supplies									292 08		
	16	77	Hardware			29 84								
	2	80	Labor and repairs							147 00				
	19	106	Castings							4 65				
	21	119	Lumber and kevels						5 12					
	28	126	Subsistence									22 10		
	28	127	......do									26 55		
	30	149	Pay-roll (April)						1,119 32			145 66	40 00	
	2	150	Eggs									3 00		
	2	151	Labor								9 50			
	2	152	Sundries			2 75								
	2	153	Meat									9 00		
	2	154	Labor								19 75			
May	11	187	Oil			15 00								
	1	191	......do			65 84								
	11	201	Pump						197 50					
	11	202	Ice									9 85		
	11	203	Labor and material							105 05				
	11	204	......do							68 25				
	2	214	Traveling expenses						6 00					
	14	231	Supplies			11 63			20					
	18	242	Subsistence									8 35		
	18	243	Transportation						6 50					
	18	244	Subsistence									80 60		
	18	245	Meat									27 00		
	22	250	Subsistence									17 60		
	22	251	Labor							10 00				
	23	256	Eggs									3 60		
	23	257	Meat									11 00		
	25	261	Subsistence						4 40			165 49		
	26	269	Supplies			45 29			70					
June	1	281	Clock					5 50						
May	31	282	Pay-roll (May)						1,143 15			146 17	41 83	
Apr.	30	283	Labor								21 50			
	30	284	Frame					85						
	30	285	Fish									1 93		
	30	286	Services						10 00					
	30	287	Subsistence									10 25		
	30	288	....do									4 63		
	30	289	Meat									13 20		
	30	290	Subsistence									4 60		
	30	291	Labor								13 12			
	30	292	Supplies			1 35								
	30	293	Subsistence									4 10		
	30	294	....do									8 95		
	30	295	Labor								5 00			
June	2	301	Subsistence									8 67		
	2	304	Plank							11 90				
	2	305	Subsistence									25 50		
	4	307	Skiffs					17 00						
	5	Part, 326	Envelopes		1 50									

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, *to October* 31, 1883, *both inclusive*—Continued.

STEAMER EMMA ETHERIDGE—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
5	327	Liner-boxes							$14 62				
May 29	360	Labor								$4 95			
29	361	Lumber, repairs							2 97				
29	362	Labor								24 24			
29	363	Subsistence									$47 30		
June 18	368	Meat									11 00		
18	371	Ice									5 00		
25	403	Repairs							115 00				
30	412	Pay-roll (June)						$1,120 98			145 00	$40 00	
May 29	413	Labor								12 62			
29	414	do								17 50			
29	415	Supplies									9 95		
July 3	1	Repairs							26 50				
2	2	Subsistence									40 40		
2	3	do									62 90		
3	9	do									160 74		
5	16	Supplies			$115 38								
6	24	Repairs							31 25				
6	29	Supplies			3 00								
14	49	Repairs							14 50				
13	52	Subsistence									2 00		
14	54	Repairs							13 40				
16	58	Supplies			14 63								
16	62	Subsistence									21 13		
17	65	Supplies			56 26								
17	66	Repairs							1 20				
19	68	Subsistence									87 60		
19	69	do									56 80		
19	71	Repairs							6 25				
24	73	Supplies			1 75								
25	84	do			8 36								
2	98	Subsistence									3 75		
2	99	do									14 95		
2	100	Labor								4 20			

	2	101	......do								2 50			
	2	102	......do								11 95			
	2	103	Subsistence									5 75		
	2	104	......do									10 20		
	2	105	Labor								14 50			
	2	106	......do								1 25			
	2	107	......do								9 02			
	31	108	Pay-roll (July)						1,210 33			108 00		
Aug.	7	143	Supplies			8 50								
	7	144	Subsistence									6 60		
	8	145	Supplies			17 42								
	8	148	Repairs							44 24				
	10	164	Supplies			13 00								
	15	181	Subsistence									63 50		
	15	185	......do									104 81		
	15	186	Repairs							12 92				
	16	191	Labor and material							20 20				
	16	197	Chains			57 97								
	16	198	Castings			16 53								
	17	199	Labor and material							37 40				
	17	200	Labor							1 00				
	17	201	Stationery		$4 50									
	17	206	Patterns							9 80				
	17	208	Supplies			1 35								
	27	220	Lumber							6 83				
	29	227	Ratchets			42 00			98					
	29	228	Supplies						2 50			32 36		
	29	229	Supplies and outfit			11 50								
	29	231	Brasses and cups							18 80				
	31	246	Pay-roll (August)						1,119 52					
	4	247	Cleaning boilers								2 50			
	4	248	Labor								20 00			
	4	249	Meat									12 56		
	4	250	Vegetables									6 20		
	4	251	Ice									5 00		
	4	252	Transportation						19 60					
	4	254	Services								10 50			
Sept.	3	289	Stores and supplies			1 75				8 40		9 80		
	1	299	......do			5 20								
Aug.	30	309	Making affidavits								1 00			
Sept.	1	310	Transportation						9 50					
	6	312	Stores and supplies			2 50				2 00				
	8	321	Traveling expenses						1 50					
	10	337	......do						1 50					
	11	338	Subsistence									27 75		
	14	361	Repairs to machinery							24 88				
	14	365	Traveling expenses						1 00					
	17	366	Stationery		5 00									
	20	393	Stores and supplies			2 20			2 50			7 65		
	24	403	Lumber							25 66				
	27	421	Meat									9 50		
	30	445	Labor								2 75			

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, *to October* 31, 1883, *both inclusive*—Continued.

STEAMER EMMA ETHERIDGE—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
Sept. 30	451	Pay-roll (September)						$45 84					
30	452	Subsistence									$17 00		
Aug. 30	454	Pay-roll						199 00					
30	462	Supplies									10 72		
30	463	Transportation						9 00					
30	464	......do						7 80					
30	465	Making affidavits		$1 50									
30	466	Eggs									2 04		
30	467	Vegetables									4 10		
Oct. 2	4	Paper		3 96									
22	30	Stores and supplies			$2 55			5 15			179 37		
22	35	Supplies			75 26			1 45					
20	43	Transportation						66 50					
20	67	Bell					$60 00	60					
22	74	Subsistence									29 25		
22	75	......do									25 80		
12	77	......do									8 00		
12	78	Pay-roll										$10 66	
25	98	Subsistence									45 95		
29	119	Pay-roll						213 51					
29	122	......do						514 00					
		Totals		65 31	2,316 28	$34 00	1,426 50	12,954 22	$1,003 94	$564 90	3,811 43	208 06	$22,381 66

CHARTERED STEAMER JOHN DIPPOLD.

Aug. 8	147	Transportation						68 00					
9	157	Medical supplies			8 50								
9	158	Supplies			11 98								
9	159	Coal				473 55							
9	160	Supplies			3 80								

	9	161	Subsistence									30 45		
	10	165	Supplies			217 56								
	13	174	Coal				312 40							
	15	180	Supplies			70 70								
	17	209	do			10 58								
	17	210	do			7 68								
	27	214	Subsistence									33 05		
	27	215	do									33 25		
	27	219	Coal				409 75							
	29	225	Subsistence									49 58		
	29	233	Lumber							8 70				
	29	234	Labor								7 50			
	29	235	Labor and material							5 65				
	29	242	Supplies			618 18								
	30	263	Subsistence									78 07		
	30	264	do									41 50		
	30	265	do									30 43		
	30	270	do									60 68		
Sept.	3	281	do									1 60		
	3	286	Charter						1,250 00					
	3	290	Coal				219 34							
	3	291	Subsistence									32 50		
	3	302	Pay-roll						1,409 91					
Aug.	6	303	Stores and supplies			28 65						17 27		
	6	304	Subsistence									9 00		
	6	305	Transportation						1 90					
	6	306	do						50					
	6	307	Subsistence									5 00		
Sept.	10	335	do									12 74		
	12	341	do									33 04		
	12	342	do									14 25		
	13	357	Coal				1,283 73							
	14	362	Subsistence									18 60		
	14	363	do									72 44		
	17	364	Coal				681 01							
	25	410	Stationery		5 45									
	30	427	Supplies			13 80								
	30	428	Supplies and stores			4 95						110 08		
	30	430	Coal				44 81							
	30	440	Charter						1,500 00					
	30	442	Stores and supplies			8 45						76 85		
	29	472	Pay-roll						1,704 45					
	3	473	Labor								16 00			
	3	474	Subsistence									30		
Oct.	2	5	Transportation						7 00					
	9	8	do						5 00					
	10	12	Subsistence (ice)									20 00		
	10	13	do									15 55		
	10	15	Subsistence (apples)									2 60		
	10	16	do									39 10		
	23	29	do						10 20			270 17		

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, *to October* 31, 1883, *both inclusive*—Continued.

CHARTERED STEAMER JOHN DIPPOLD—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
Oct. 22	82	Labor								$16 00			
22	83	Coal				$291 51							
22	89	Supplies			$206 52			$3 36					
9	81	Pay-roll						405 33					
Sept. 29	82	Telegram		$0 95									
29	84	Labor								1 25			
29	85	Oil			3 00								
Oct. 2	88	Transportation						7 00					
		Totals		6 40	1,199 20	3,665 60		6,372 65	$14 35	40 75	$1,208 60		$12,507 55

CHARTERED STEAMER REINDEER.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
Sept. 8	289	Subsistence									26 15		
1	299	do									11 95		
1	300	Supplies			1 92								
5	301	Stores and supplies			2 00	5 00					6 85		
Aug. 30	308	Pay-roll						811 18					
Sept. 6	312	Subsistence									20 35		
6	313	Coal				6 50							
12	345	Pay-roll						148 80					
12	347	Coal and subsistence				42 00					13 75		
13	358	Coal				56 00							
14	397	Services						8 00					
Oct. 22	50	Coal				24 00							
		Totals			3 92	133 50		467 98			79 05		684 45

CHARTERED STEAMER MINNETONKA.

Sept.	7	317	Material and supplies			194 16								
	17	366	Stationery		5 00									
	17	371	Supplies			86 00			2 85					
Oct.	2	4	Paper		8 96									
	22	36	Supplies			42 29			90					
	22	52	Stores and supplies			75						56 85		
	22	60	Medicines									15 02		
	20	64	Frames						4 50					
	22	72	Stores and supplies			33 15			6 50			281 21		
	22	73	Supplies			3 74								
	22	76	Coal				427 60							
	15	120	Labor						19 42					
	29	128	Pay-roll						278 92					
			Totals		8 96	360 09	427 60		307 59			302 58		1,406 82

CHARTERED STEAMER JACK FROST.

Sept.	10	335	Subsistence									6 37		
	18	376	do									30 15		
	18	380	Subsistence and supplies			90						353 31		
	18	381	Supplies			38 20								
	21	395	Stationery		7 25									
	25	406	Supplies			6 00								
	25	411	Stationery		3 50									
	30	432	Subsistence									40 60		
	30	436	Coal				160 00							
	30	438	Subsistence and supplies			1,613 48						22 66		
	30	439	Charter						800 00					
	30	453	Pay-roll (September)						891 00					
Aug.	30	455	Supplies			15 00								
	30	456	Traveling expenses						2 50					
	30	457	Subsistence									12 00		
	30	458	do									10 84		
	30	459	Fender			2 10								
	30	460	Traveling expenses						2 50					
	30	461	Subsistence									9 65		
	30	468	do									4 50		
	30	469	Labor								6 00			
	30	470	Hauling						75					
Oct.	2	4	Paper		1 82									
	10	14	Ice									15 08		
	10	18	Subsistence									25 50		
	10	19	Meat									22 50		
	22	81	Coal				559 12							
	22	82	do				327 47							

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, *to October* 31, 1883, *both inclusive*—Continued.

CHARTERED STEAMER JACK FROST—Continued.

Date.	Voucher.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
Sept. 22	41	Stores and supplies			$63 34			$2 10			$0 90		
22	57	Coal				$84 60							
20	71	Hose					$19 25						
29	116	Charter						800 00					
29	117	Pay-roll						841 57					
Sept. 30	118	Labor								$4 00			
		Totals		$12 07	1,739 02	1,131 19	19 25	3,340 42		10 00	554 01		$6,805 96

PLUM POINT REACH.

Capt. J. G. D. Knight.

Date.	Voucher.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1882.													
Dec. 1	215	Fire brick and clay			12 50			6 05					
1	216	Subsistence						22 75			562 50		
	217	do									221 25		
Dec. 2	218	do						1 00			28 90		
4	221	Stone			368 33								
1	228	Outfit, quarter-boats					13 50	1 00					
2	232	Subsistence						17 85			466 29		
4	234	do						10 50			270 00		
5	236	Supplies			27 50			1 00					
6	245	Rope			134 37								
12	254	Towage						48 00					
4	266	Material			115 79			4 25					
11	267	Subsistence						44 30			870 10		
11	270	Outfit, quarter-boats					108 25	7 30					
18	271	do					600 00						
16	274	Stone			317 00								
19	278	Iron					436 90	18 48					

	283	"Construction Itaska"					428 41						
Dec. 21	284	Subsistence									890 50		
23	285	Traveling expenses	$12 40										
22	290	Loading stores						21 60					
22	293	Subsistence									185 94		
22	295	Snatch blocks					160 12	55					
19	296	Subsistence						18 42			675 00		
19	297	......do						22 59			1,132 70		
11	302	Outfit					108 27	3 95					
20	304	Supplies			2,579 47			18 55					
19	306	......do			21 24			85					
20	308	Subsistence						83 80			1,694 85		
25	311	Outfit					154 83	1 65					
9	312	......do					20 80	65					
26	318	Copying official papers		$12 40									
1888.													
Jan. 6	9	Gum cutters			4 00								
6	13	Transportation						5 58					
5	24	Outfit, quarter-boats					720 00	9 70					
15	26	Services										$6 50	
6	27	Supplies			72 82			8 70					
6	28	Straw			56 49			20 00					
9	31	Washing-machines			288 00			3 10					
4	34	Advertisement for material			15 41								
9	35	Advertisement for stone			22 80								
10	36	Labor						7 00					
4	37	Advertisoment for material			20 72								
16	40	Salt					76 25						
15	42	Mileage	11 84										
25	43	Supplies			295 79			6 40					
29	47	Apples						5 00			75 00		
25	49	Skiffs					102 00						
17	51	Lamps			74 75								
17	53	Blocks			115 20			3 15					
17	55	Labor and material					17 82						
16	56	Door-liners						10 52					
17	60	Supplies (sub)						34 60			757 78		
5	63	Outfit, quarter-boats					2,318 74	28 70					
25	67	Stone			1,147 75								
25	72	Oil			190 30								
25	90	Outfit, graders					378 00	8 10					
25	92	Tarpaulins										162 50	
25	93	Duck						261 95					
25	95	Supplies			210 40								
25	97	Stores and supplies			87 15						24 64		
26	103	Subsistence									135 26		
16	106	Supplies			167 93						49 23		
29	107	Outfit, quarter-boats					9 66						
25	108	Transportation						8 00					
27	110	Supplies			15 00						66 00		
27	112	......do			21 20						107 40		
27	114	Outfit, quarters					230 33						

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, *to October* 31, 1883, *both inclusive*—Continued.

PLUM POINT REACH—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
Jan. 31	120	Services	$30 00										
29	122	Supplies			$137 04						$18 62		
29	123	Anchors					$195 75						
29	125	Vinegar									24 93		
29	126	Outfit, quarters					190 21						
30	128	Apples									73 13		
30	136	Supplies			38 20								
30	142	Transportation						$53 58					
31	144	Pencils		$31 80									
30	154	Services	108 33										
31	159	Labor (loading stores)						8 00					
Feb. 3	163	Outfit, quarters					46 40						
3	174	Services										$32 00	
3	175	Stone			683 10								
Jan. 25	183	Traveling expenses	8 00										
Feb. 7	188	Wire			3,084 06			75 58					
6	195	......do			7,542 11			164 69					
12	198	Mess outfit					148 45						
2	203	Transportation						65					
15	204	Supplies			3,461 70								
15	206	Outfit					335 56						
14	208	Services										14 00	
16	211	Supplies			66 60						890 65		
16	212	......do									104 98		
17	213	Hardware			25 70								
16	215	Bolts and rope			35 63								
16	217	Can fruit									85 60		
16	218	Sugar									197 60		
17	224	Subsistence									445 09		
20	236	Transportation						35 50					
22	237	Lumber			369 41								
23	238	Salt									8 15		
22	241	Books and reports		17 70									
23	243	Buckets			151 20			3 75					

	23	244	Stores			138 00			5 80					
	10	249	Advertising for material			10 50								
	27	253	Services	100 00										
Jan.	30	271	Labor						10 50					
Mar.	2	275	..... do						31 05				15 00	
	3	281	Transportation						28 00					
	3	283	Rope			947 86			21 60					
	5	287	Tape and rule					4 15						
	5	289	Hams						1 00			84 44		
Feb.	24	291	Advertising for materials			11 90								
Mar.	6	294	Knobs			4 00			1 00					
	7	298	Grate-bars			86 85			2 60					
	6	299	Supplies			416 28			10 75					
	7	300	Rope			284 90			6 50					
	8	302	Towing						5 00					
	8	304	Brushes			62 50			1 00					
Feb.	24	305	Advertising for material			11 42								
	27	313	Stone			407 74								
Mar.	5	318	......do			405 40								
	12	324	Labor						30 00					
	14	328	Supplies						2 75			90 20		
	24	345	Labor						37 18					
	24	346	Lumber			226 03								
	24	347	Hose			78 75			1 00					
	24	353	Supplies			268 63			2 80					
	24	356	Books			5 50								
	26	358	Potatoes						17 50			125 00		
	28	367	Skiffs and oars					260 50						
	31	377	Services	37 50										
	31	383	.....do	62 50										
	30	384	Wire			4,018 30								
Apr.	2	6	Services	37 00										
	6	16	Labor						13 08					
	7	25	Towage						10 00					
	9	36	Supplies			59 78								
	9	37	Reducers			5 00								
	10	39	Straw			37 80								
	10	41	Outfit					4 92						
	10	43	......do					426 50	6 75					
	11	47	Supplies					20 70						
	11	50	Ranges					285 00						
	12	56	Stationery		13 75									
	12	57	Outfit					96 70	2 00					
	13	61	......do					212 65	5 82					
	13	62	Supplies			287 34								
	13	65	.....do			75 58						669 98		
	14	68	Outfit					553 08						
	11	69	Traveling epenses	26 70										
	14	70	Hoisting-engine					1,585 00						
	6	73	Labor						67 50					
	6	74	Stone			212 85								
	16	76	Hardware			256 62								

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, *to October* 13, 1883, *both inclusive*—Continued.

PLUM POINT REACH—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
Apr. 16	78	Straw			$24 20								
16	81	Supplies					$63 75	$1 00					
16	82	do			151 20			2 81					
16	83	Outfit					637 50	8 75					
16	84	Subsistence						39 30			$1,067 96		
17	86	do						24 00			580 00		
17	87	Hardware			17 01			1 00					
17	88	Subsistence						1 00			57 80		
17	89	Rubber boots			54 27			1 00					
17	93	Outfit			46 08			50					
17	94	Labor and material										$35 10	
17	95	Supplies			3 00								
17	96	Paint			250 50								
17	97	Liner-boxes							$8 40				
18	99	Supplies			105 24			22 85			360 00		
18	100	do						8 20			240 40		
18	101	Outfit					480 40	9 02					
18	102	Subsistence						16 85			313 65		
18	104	Outfit					10 28						
19	107	do					72 28	1 00					
19	109	do					65 32						
19	110	do					172 91						
19	111	do					261 34						
19	113	Stone			125 77								
19	114	Wire rope			803 68			22 50					
20	115	Outfit					527 80						
20	117	Chairs					5 25	1 00					
20	118	Blocks					156 30	2 80					
21	120	Subsistence						1 00			30 00		
21	121	Outfit					18 58						
21	122	do					240 00	8 75					
21	123	Services						15 00					
23	129	Pumping boat					600 00						
24	132	Ice-chest					55 00						

	27	137	Pump					102 00	1 00					
	30	155	Services	$62 50										
	30	156	......do	40 00										
May	1	165	Labor						15 39				7 11	
Apr.	30	169	Services	62 50										
May	4	171	Sheeting					25 00						
	7	174	Towage						5 00					
	11	179	Stone			1,049 60								
	11	180	Labor										27 80	
	11	184	Supplies			170 64								
	11	188	......do			938 88		352 00						
	7	194	Outfit					1,441 07	28 65					
	11	195	Supplies			592 62								
	11	196	Hardware			87 10								
	11	197	Lamps			23 40								
	11	198	Lumber			438 68								
	11	199	File			5 88								
	11	200	Wire			4,559 99								
	11	216	Quarter-boats					8,000 00						
	14	230	Supplies			483 62			5 70					
	16	233	Barges					3,975 00						
	16	234	Labor and material										8 13	
	16	236	Supplies			7 75			2 67			105 71		
	16	237	do										10 60	
	19	246	Hose					1,500 00	6 00					
	5	249	Transportation						1 00					
	28	253	Capstan					176 00	6 70					
	28	254	Barge					1,250 00						
	25	259	Bits						1 00	10 00				
	25	260	Tools			82 00			1 12					
	23	262	Transportation						75					
	26	265	Tracing linen		$17 00									
	26	270	Supplies			42 62			65					
	22	273	Stone			990 00								
	28	275	Services	50 00										
	28	276	......do	31 25										
	28	277	......do	50 00										
	28	298	Ice-chests					24 00	2 35					
June	2	302	Services		28 00									
	2	303	Towage						10 00					
	4	308	Skiffs and oars					169 50						
	4	314	Salt					34 56						
	4	316	Napkins					15 90						
	5	317	Supplies			320 10								
	5	319	Rope			9 26								
	5	320	Beef									725 00		
	5	321	Winch heads			53 76								
	5	322	Labor						9 00					
	5	324	Electric-light machinery					881 00						
	5	325	......do					1,570 00						
	5	328	Stone			1,358 28								
	5	329	Labor and material										86 80	

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, *to October* 31, 1883, *both inclusive*—Continued.

PLUM POINT REACH—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
June 7	330	Salt					$24 84						
7	332	Jack-screws			$21 00			$0 60					
8	333	Supplies			36 00						$1,255 88		
8	334	do			38 17						184 64		
8	335	do			213 24			4 80					
8	339	do		$9 00									
7	340	Barge					1,250 00						
8	341	Traveling expenses	$6 40										
8	345	Labor and oil										$14 56	
8	346	Stone			239 85								
8	347	Salt					14 58						
4	348	Barges					5,200 00						
4	349	do					2,700 00						
8	357	Towage						10 00					
8	358	Labor, &c. (electric light)					108 85						
18	364	Mattress-boats and barges					6,400 00						
18	365	Barge					1,250 00						
18	367	Salt						20 00			62 50		
18	369	Gauges			15 00								
18	370	Barges					2,600 00						
18	372	Towage						12 50					
18	374	Extract						65			66 80		
18	375	Stores and supplies			102 60			119 50			2,784 19		
18	381	Stationery		15 50									
18	382	Supplies			99 06			3 80					
18	383	do			999 18			16 05					
18	384	Drills			8 82			1 00					
18	385	Mosquito-bars					45 28	50					
18	386	Fire tile and clay			22 10			8 85					
18	387	Hose-bands			17 50			50					
18	388	Beef						16 70			362 50		
7	389	Barges					5,308 00						
18	390	do					8,981 00						
21	302	Supplies			325 20			2 65					

	21	398	Rope			846 08			18 80					
	7	396	Barges					4,050 00						
	25	404	Salt					68 04						
	29	422	Services	50 00										
	29	423	......do	50 00										
	29	424	......do	25 00										
	30	427	Charter of steamer						525 00					
	29	428	Barge					1,250 00						
July	5	4	Traveling expenses	13 75										
	3	5	Hose			36 30								
	3	6	Supplies			2 25						471 80		
	3	10	......do			91 05								
	3	11	......do			135 90			24 45					
	5	19	......do			105 00			1 10					
	5	20	......do			16 20								
	6	30	Subsistence						7 45			77 84		
	6	31	Supplies			96 00			1 48					
	9	33	Towage						400 00					
	3	34	Stone			880 55								
	3	35	Services										8 20	
	9	37	Subsistence						4 20			87 52		
	9	40	Supplies			7 60			50					
	14	41	Barge					1,250 00						
	10	42	Ice									2,012 50		
	12	46	Supplies			82 50			2 40					
	13	50	Traveling expenses	7 25										
	14	53	Services										17 04	
	12	57	Mattress-boat					4,960 00						
	17	59	Supplies			16 74								
	17	60	Stone			270 27								
	18	61	Services										9 80	
	17	63	Barges					2,650 00						
	17	64	Labor and material			40 74				62 25			85 82	
	23	74	Subsistence						24 80			699 03		
	25	76	Supplies			65 00								
	25	77	Towage						450 00					
	24	79	Supplies			1,841 40			28 07					
	24	80	......do			20 00			50					
	25	81	Whitehall boats					339 00						
	25	83	Subsistence						12 53			838 69		
	27	85	Supplies			63 45			50					
	27	86	......do			69 50			1 00					
	27	88	......do			11 50			1 00					
	26	91	Towage						125 00					
	2	97	Traveling expenses	19 50										
	30	110	Supplies			12 15								
	31	116	Services	83 33										
	30	117	......do	50 00										
Aug.	1	118	Charter						542 50					
	2	123	Towage						27 50					
	2	124	Lumber					11 75						
	2	126	Services	50 00										

Itemised statement of expenditures for improving the Mississippi River, from December 1, 1882, *to October* 31, 1883, *both inclusive*—Continued.

PLUM POINT REACH—Continued.

Date.		Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.														
Aug	8	129	Wire			$6,226 74								
	8	132	Material and labor			921 71				$5 00			$12 60	
	6	135	Traveling expenses	$17 60										
	6	140	Mattress-boat					$4,200 00						
	2	150	Labor (coaling)						$2 85					
	9	155	Mattress-boat					5,400 00						
	9	156	Material and labor			9 76				12 75				
	10	162	Loading stores						7 79					
	10	163	Medical supplies			14 00								
	10	166	Stone			156 78								
	10	167	Services										25 44	
	13	168	Subsistence									$725 00		
	13	169	Supplies			30 00								
	13	171	Subsistence									35 70		
	13	172	Supplies			2 50								
	13	173	do			98 20								
	13	175	Labor (loading stores)						23 75					
	13	176	Subsistence									772 95		
	13	178	Traveling expenses	3 50										
	15	179	Supplies			709 84								
	15	182	do			7 44								
	15	183	do			18 75								
	15	184	do			139 01						1,455 63		
	15	187	Material and labor							8 16				
	15	190	Stone			393 43								
	16	193	Transportation						1 00					
	16	194	Supplies			15 60								
	16	195	do			122 83			1 90					
	17	207	do			469 30								
	17	212	do			87 50								
	27	213	do			10 00								
	27	217	Meters					32 50						
	27	218	Labor							25				
	27	221	Transportation						15 00					

27	222	Dockage and repairs							5,576 60				
27	223	Labor and material							411 45				
27	224	Hulls (quarter boats)					1,000 00						
27	226	Towage						8 00					
29	229	Skiffs			17 04								
29	232	Supplies			24 75								
29	238	Subsistence									35 70		
29	239	Superstructure (quarter boats)					920 00						
29	241	Supplies			334 10								
4	255	Traveling expenses	6 25										
4	257	do	10 00										
4	259	do	8 32										
4	260	Labor (loading stores)						2 00					
4	262	Transportation						1 55					
30	266	Subsistence									613 96		
30	269	Supplies			9 50								
30	271	Subsistence						4 90			24 50		
30	272	do									363 98		
31	274	Services	50 00										
30	275	Labor (loading lumber)						4 50					
31	276	Services	50 00										
Sept. 3	282	Supplies			72 78						21 55		
3	284	Charter						542 50					
3	292	Labor and material							12 65			9 20	
4	294	Lumber			571 98								
1	297	Services	50 00										
7	314	Towage						25 00					
7	316	Labor and material							356 09				
7	320	Transportation						50					
6	324	do						37					
10	329	Ice									1,407 00		
10	330	Labor and material							208 95				
12	340	Traveling expenses	5 00										
12	343	Stone			204 75								
12	344	Labor										10 96	
12	346	Charter						90 00					
13	348	Office supplies		6 85									
13	352	Supplies			24 00			1 00					
13	353	Rope			390 16			6 15					
13	355	Subsistence						1 00			27 02		
13	356	Coal				1,742 76							
17	357	Subsistence						20 82			791 24		
17	370	Services										2 80	
18	379	Traveling expenses	2 00										
19	382	Coal				16 50							
5	383	Stone			1,834 27								
5	384	Labor and material							47 20			21 60	
5	385	Transportation						210 00					
20	392	Wire			4 50								
21	396	Gauges			4 00								
25	408	Transportation						3 10					
28	423	Labor (loading stores)						5 00					

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, *to October* 31, 1883, *both inclusive*—Continued.

PLUM POINT REACH—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883													
Sept. 30	424	Services	$50 00										
July 12	429	Hose			$194 29								
Sept. 30	437	......do			270 00			$1 00					
29	447	Services	50 00										
30	448	Charter						525 60					
30	449	Lumber			290 50								
Oct. 10	21	Labor										$5 40	
10	22	Stone			786 26								
10	23	Towage						150 00					
10	24	Service of steamer										54 00	
22	25	Subsistence						69 04			$1,455 90		
22	27	......do						8 80			486 38		
22	34	Towage						6 60					
22	37	Supplies			29 62			70					
22	40	......do			117 41			3 80					
22	45	Labor and material							$849 58				
22	46	Hardware			180 27								
22	47	......do			8 20								
22	48	Freight						2 54					
22	49	Sieves			2 88								
22	53	Outfit					$47 55						
22	54	......do					12 90	1 42					
22	56	Beef						87 12			725 00		
22	58	Subsistence						44 95			747 78		
20	61	Stationery		$38 35									
20	65	Lamps					72 60	4 50					
Sept. 29	88	Labor						2 00					
25	94	Potatoes						18 65			80 06		
25	95	Blanks		16 75									
25	96	Chain					20 80	36					
26	99	Bags			600 00			28 10					
29	104	Skiffs					300 00						
29	106	Subsistence									159 08		
29	107	Brackets					36 00	1 00					

20	108	Insect powder			16 50			50					
20	111	Pumps					18 75	1 25					
		Total	1,888 42	207 10	64,654 72	1,765 26	88,507 03	5,968 37	7,069 28		82,189 05	632 96	202,487 19

NEW MADRID REACH.

Capt. T. G. D. Knight.

1882.													
	91	Traveling expenses	80 10										
	181	Services	45 00										
	187	Stationery		8 00									
	198	Machinery					4,200 00						
Dec. 2	222	Barges					5,550 00						
	223	......do					9,245 00						
Dec. 2	230	Towage						715 00					
	237	Barges					9,750 00						
Dec. 7	243	Pile-driver leads					8,250 00						
9	253	Traveling expenses	15 00										
9	257	Services										12 00	
13	261	Pile-driver hulls					27,000 00						
11	262	Repairs						23 16					
18	272	Towage						350 00					
19	273	Barges					8,700 00						
20	275	Towage						60 00					
30	279	Services	37 50										
30	280	......do	25 00										
23	313	Traveling expenses	6,75										
1883.													
Jan. 2	1	Barges					5,400 00						
3	3	Pile-driver leads, &c					8,250 00	430 00					
2	4	Towage						25 00					
Feb. 6	17	Traveling expenses	11 75										
Jan. 8	25	......do	21 12										
15	26	Services										6 50	
15	33	Barges					15,600 00						
15	39	Traveling expenses	11 00										
16	40	Salt					76 25						
25	75	......do					52 65						
Feb. 7	115	Rope			$86 18			1 50					
5	116	Pumps					2,070 00						
Jan. 31	118	Services	95 00										
2	155	Barges (coal)					550 00						
Feb. 6	176	Barges					1,850 00						
6	177	......do					10,050 00						
6	178	......do					2,000 00						
12	182	Pumps					4,960 00						

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, *to October* 31, 1883, *both inclusive*—Continued.

NEW MADRID REACH—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
Feb. 21	227	Hauling						86 00					
24	228	Hose			600 00								
Mar. 1	260	Barges					7,200 00						
2	276	Salt					98 55						
2	279	Pile-driver hulls and barges					5,950 00						
2	280	Traveling expenses	$5 00										
5	292	Pump					650 00						
6	293	Services	100 00										
8	311	Couplings					80 60						
9	312	Hose					100 00						
13	326	Barges					8,600 00						
26	361	do					1,800 00						
29	372	Machinery					9,295 25						
31	376	Services	75 00										
Apr. 6	9	Machinery					4,784 58						
9	32	Towage						60 00					
9	35	Machinery					4,794 68						
16	79	do					1,715 79						
9	98	Quarter-boats, barges, and pile-driver hulls					5,950 00						
18	105	Machinery					4,784 58						
21	124	do					5,839 15						
May 11	217	Pile-driver hulls					4,500 00						
11	218	Machinery					5,172 82						
11	219	do					4,782 88						
11	224	Traveling expenses	12 95										
25	263	Steam-fittings					971 97						
June 18	366	Labor, repairs							$20 00				
23	401	Extra work					2,536 00						
27	409	Labor and material					2,404 40						
Sept. 13	359	Repairs							9 50				
		Total	491 17	3 00	686 18		187,195 63	1,870 66	29 50			18 50	190,294 64

MEMPHIS REACH AND HARBOR.

MAJ. A. M. MILLER.

1882.													
	91	Traveling expenses	$4 30										
	95	Towage						$150 00					
	103	Traveling expenses	10 95										
	181	Services	80 00										
	182	......do	125 00										
	185	Boats					$13,500 00						
	187	Stationery		$2 00									
	198	Machinery					4,200 00						
Dec. 1	210	Rope			$552 97			11 70					
1	212	Subsistence						5 40			$82 80		
4	221	Stone			109 67								
4	227	Subsistence						8 50			225 93		
2	230	Barges					30,000 00						
5	233	Supplies			91 75			3 00					
7	242	Coal boat					1,200 00						
6	245	Rope			67 17								
8	250	Wire			1,248 10			60 89					
12	254	Towage						87 00					
	256	Traveling expenses	48 75										
Dec. 13	261	Screen-boats					4,500 00						
13	265	Spikes			343 20			25 80					
18	272	Towage						595 00					
16	274	Stone			112 00								
19	277	Barges					6,000 00						
30	280	Services	100 00										
30	281	...do	125 00										
18	303	Rope			184 05								
4	309	Spikes			77 40			3 60					
1883.													
Jan. 2	1	Quarter-boats					1,200 00						
2	2	Barges					10,000 00						
8	14	.....do					5,880 00						
8	25	Traveling expenses	21 12										
15	26	Services										$6 50	
9	29	Services, pilot						50 00					
16	40	Salt					76 25						
15	45	Services, pilot						54 00					
29	46	Subsistence									351 74		
25	49	Skiffs					660 00						
17	57	Towage						5 00					
15	61	Traveling expenses	41 30										
25	65	Outfit					123 59	1 95					
5	67	Stone			302 75								
25	71	Outfit					130 16	1 70					
25	77	Subsistence									617 45		

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

MEMPHIS REACH AND HARBOR—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
Jan. 25	78	Salt					$17 55						
17	91	Traveling expenses						$24 60					
27	111	Outfit					117 50	1 60					
31	118	Services	$25 00										
31	119	do	125 00										
31	120	do	48 33										
2	155	Coal barges					550 00						
Feb. 5	167	Traveling expenses	8 05										
3	174	Services										$32 00	
3	175	Stone			$194 54								
6	177	Barges					3,820 00						
12	179	Towage						45 00					
12	180	Charter						465 00					
Jan. 25	183	Traveling expenses	3 00										
Feb. 12	184	Rope			111 29								
Jan. 16	193	Superstructure, quarter boat					1,541 00						
31	194	do					1,176 00						
Feb. 6	196	Wire			2,316 90								
15	200	Labor						8 50					
20	207	Towage						200 00					
14	208	Services										14 00	
Jan. 6	209	Traveling expenses	50 25										
Feb. 19	226	Towage						10 00					
27	253	Services	25 00										
Mar. 2	274	Charter						420 00					
2	280	Traveling expenses	1 25										
6	293	Services	25 00										
6	295	do	125 00										
8	306	Towage						100 00					
12	308	Stone			221 13								
Feb. 27	313	do			268 25								
Mar. 5	318	do			1,420 16								
12	324	Labor										30 00	
24	344	Pile-driver heads					3,040 00						

	24	356	Books			5 50								
	24	357	Salt					89 10						
	28	369	Pile-driver hulls					5,850 00						
	29	370	Anchors					488 78						
	31	374	Towage						10 00					
	31	376	Services	50 00										
	31	377	do	50 00										
	31	380	Charter						465 00					
Apr.	6	18	Services						25 50					
	9	32	Towage						90 00					
	9	33	Pile-driver hulls					3,900 00						
	6	73	Labor										58 50	
	6	74	Stone			1,078 11								
	17	93	Pile-driver hulls					5,850 00						
	23	129	Pumping-boat					300 00						
	30	156	Services	45 00										
May	11	179	Stone			524 80								
	11	180	Labor										18 90	
	11	222	Charter						450 00					
	16	234	Labor and material										55 05	
	12	239	Pumps					4,160 00						
	22	273	Stone			495 00								
	28	275	Services	25 00										
	28	276	do	62 50										
	28	277	do	25 00										
	28	279	Charter						465 00					
June	2	308	Towage						5 00					
	4	314	Salt					17 28						
	5	328	Stone			679 14								
	5	329	Labor and material										43 40	
	7	330	Salt					12 42						
	8	341	Traveling expenses	3 20										
	8	345	Labor, &c										7 28	
	8	346	Stone			119 93								
	8	347	Salt					7 29						
	8	357	Towage						5 00					
	18	366	Labor							$16 00				
	21	394	Machinery					12,931 60						
	23	400	Extra work on plant					272 00						
	25	404	Salt					34 02						
	27	410	Labor and material					141 11						
	29	422	Services	25 00										
	29	423	do	25 00										
	29	426	Charter						450 00					
July	3	34	Stone			190 29								
	3	35	Labor										4 10	
	14	53	do										8 52	
	17	59	Salt			8 37								
	17	60	Stone			185 18								
	18	61	Labor										4 90	
	2	97	Traveling expenses	9 75										

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, *to October* 31, 1883, *both inclusive*—Continued.

MEMPHIS REACH AND HARBOR—Continued.

Date.		Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.														
Aug.	1	119	Chartered						$465 00					
	2	124	Lumber					$5 89						
	2	126	Services	$25 00										
	8	132	Stone			$460 86				$2 50			$6 30	
	10	166	......do			78 39								
	10	167	Labor										12 72	
	15	187	Lumber							4 09				
	15	190	Stone			196 71								
	27	226	Towage						4 00					
	4	259	Traveling expenses	4 16										
	30	269	Paper			5 00								
	31	274	Services	25 00										
	31	276	......do	25 00										
Sept.	3	288	Charter						465 00					
	8	292	Labor and material							6 33			4 60	
	1	297	Services	25 00										
	7	316	Labor and material							178 05				
	12	340	Traveling expenses	2 50										
	12	343	Stone			102 88								
	12	344	Labor										5 48	
	13	359	Labor and material							9 50				
	17	370	Labor										1 40	
	18	379	Traveling expenses	1 00										
	5	383	Stone			917 14								
	5	384	Labor and material							23 60			10 80	
	5	385	Labor						105 00					
	30	424	Services	25 00										
	30	425	Charter						450 00					
	29	447	Services	25 00										
Oct.	10	21	Labor										2 70	
	10	22	Stone			303 13								
	10	23	Towage						75 00					
	10	24	Services of steamer										27 00	

22	34	Towage						3 00					
22	45	Labor and material							185 88				
		Total	1,470 41	$2 00	12,956 21		121,791 54	5,870 74	425 95		$1,277 92	349 15	$144,143 92

LAKE PROVIDENCE REACH.

Capt. W. L. Marshall.

1882.													
	95	Towage						175 00					
	149	do						125 00					
	183	Services	104 17										
	196	Charter						495 00					
	204	Barge					2,000 00						
	205	Iron			161 76			18 30					
	207	Subsistence						39 50			382 15		
	208	Stores and supplies			125 06			96 37			1,517 04		
	209	do			25 50			84 00			581 80		
	214	do			24 24			43 00			647 27		
Dec. 6	245	Rope			67 17								
9	253	Traveling expenses	6 00										
12	258	Barge					2,000 00						
16	268	do					2,000 00						
18	272	Towage						35 00					
18	276	Barge					2,000 00						
30	279	Services	87 50										
30	282	do	125 00										
23	285	Traveling expenses	12 40										
30	288	Charter						465 00					
22	290	Loading stores						21 60					
22	291	Subsistence									148 82		
22	292	do									17 25		
19	298	do						6 00			197 14		
19	299	do						11 00			246 90		
19	300	do						11 00			237 50		
19	301	do						14 74			540 00		
20	307	Stores and supplies			272 41			37 91			1,956 63		
23	313	Traveling expenses	15 75										
1883.													
Jan. 2	1	Barges, &c					2,400 00						
4	5	Barges					2,000 00						
6	8	Subsistence									58 75		
8	11	Barge					2,000 00						
6	12	do					2,000 00						
Feb. 6	17	Traveling expenses	11 75										
Jan. 15	26	Services										6 50	
15	39	Traveling expenses	11 00										

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, *to October* 31, 1883, *both inclusive*—Continued.

LAKE PROVIDENCE REACH—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
Jan. 16	41	Tow-boat Charlie De Pauw					$17,404 00						
15	45	Services, pilot						$18 00					
25	49	Skiffs					100 00						
16	52	Barges					2,000 00						
5	67	Stone			$666 50								
25	96	Oil			27 00								
25	98	Stores and supplies			53 29						$465 47		
26	99	Beef									500 00		
26	100	Flour									115 00		
26	101	Hams									84 28		
26	102	Subsistence									329 46		
26	105	Supplies			132 75						390 72		
27	109	do			67 20						224 54		
27	113	do			87 60						1,255 88		
31	117	Services	$125 00										
31	118	do	5 00										
31	120	do	30 00										
29	121	Supplies			5 25						355 90		
29	124	do			20 25						528 76		
30	127	Subsistence									57 26		
30	134	Charter						485 00					
Feb. 3	140	Barges					2,000 00						
Jan. 30	143	Transportation						163 20					
Feb. 1	145	Flour									254 40		
2	160	Subsistence						61 89			518 85		
5	162	Barge					2,000 00						
8	168	Peas						85			14 00		
8	174	Services										$82 00	
8	175	Stone			1,684 49								
12	179	Towage						250 00					
Jan. 25	183	Traveling expenses	7 00										
Feb. 2	187	Barges					4,800 00						
2	199	Transportation						2 14					
14	208	Services										14 00	

	15	220	Barge					2,000 00						
	22	241	Books and reports		$13 10									
Mar.	1	245	Barges					9,600 00						
	1	247	Potatoes									135 60		
	1	262	Charter						540 00					
	1	263	Services	125 00										
	2	277	Towage						1,000 00					
	5	286	......do						200 00					
	8	306	do						100 00					
	12	308	Stone			110 57								
	12	309	Material			47 50								
	8	310	Services	125 00										
Feb.	27	318	Stone			221 18								
Mar.	5	318	......do			500 94								
	12	324	Labor										30 00	
	24	350	Books			5 50								
	26	361	Barges					2,400 00						
	24	366	Transportation						824 48					
	29	371	Anchors					110 97	6 58					
	31	377	Services	37 50										
	31	378	......do	125 00										
	31	381	Charter						558 00					
	30	383	Services	62 50										
	31	384	Wire			7,218 72								
Apr.	2	5	Capstan					502 40						
	6	10	Traveling expenses	32 10										
	6	16	Labor						20 00					
	6	17	Traveling expenses	27 80										
	6	21	Subsistence									96 88		
	7	25	Towage						10 00					
	7	31	Services	16 67										
	10	44	Outfit					164 63						
	10	45	......do					127 18						
	10	46	......do					465 00						
	11	51	Ranges					372 40						
	11	52	Outfit					480 13						
	12	58	......do					50 50	50					
	6	74	Stone			1,318 78								
	9	75	Traveling expenses	50 75										
	9	98	Plant					16,000 00						
	19	112	Outfit					1,080 20						
	19	113	Stone			234 00								
	20	116	Outfit					50 00						
	21	123	Services						10 00					
	23	128	Rope			116 39								
	23	129	Pumping boat					600 00						
	24	131	Ice-chests					110 00						
	26	135	Supplies						58 90			599 86		
	26	136	......do						24 40			437 85		
	27	138	Wire			5,537 00								
	27	139	Outfit					30 15						
	27	140	Subsistence						15 15			174 44		

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, *to October* 31, 1883, *both inclusive*—Continued.

LAKE PROVIDENCE REACH—Continued.

Date.		Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.														
Apr.	28	142	Supplies			$28 00			$12 20			$154 49		
	28	143	Subsistence						21 45			364 48		
	30	148	Charter						540 00					
	30	155	Services	$62 50										
	30	156	......do	40 00										
May	1	165	Labor						17 11				$7 89	
	1	169	Services	62 50										
	7	174	Towage						5 00					
	11	179	Stone			1,049 60								
	11	180	Labor										27 80	
	11	220	Mattresses					$249 60						
	11	221	Charter						374 00					
	11	225	Anchors					254 61						
	12	228	Towage						100 00					
	12	229	Coal				$150 00							
	16	233	Barges					3,975 00						
	16	234	Labor and material										24 42	
	16	237	Labor, &c										10 60	
	17	240	Transportation						27 50					
	23	254	Barge					1,250 00						
	26	268	Supplies			117 25			104 55			3,066 83		
	26	271	Beef						25 60			580 00		
	21	272	Barge					1,300 00						
	22	273	Stone			990 00								
	28	275	Services	50 00										
	28	276	......do	31 25										
	28	277	......do	50 00										
	28	278	Charter						527 00					
June	2	303	Towage						10 00					
	4	314	Salt					84 56						
	5	328	Stone			1,858 28								
	5	329	Labor and material										86 80	
	7	330	Salt					24 84						
	8	336	Rope			1,769 48								

	7	340	Barge					1,250 00						
	8	341	Traveling expenses	6 40										
	8	345	Labor and oil										14 56	
	8	346	Stone			239 85								
	8	347	Salt					14 58						
	4	348	Barges					5,200 00						
	4	349	do					2,700 00						
	8	357	Towage						10 00					
	18	364	Mattress boats and barges					13,800 00						
	18	365	Barges					1,250 00						
	18	370	do					2,600 00						
	18	372	Towage						12 50					
	18	379	Transportation						10 10					
	7	389	Barges					5,808 00						
	18	390	do					8,981 00						
	18	395	Labor (repairs)							$16 70				
	7	396	Barges					4,050 00						
	23	397	do					8,920 00						
	23	398	Labor					10 00						
	25	404	Salt					68 04						
	27	408	Transportation						39 35					
	29	422	Services	50 00										
	29	423	do	50 00										
	29	424	do	25 00										
	29	425	Charter						510 00					
	29	428	Barge					1,250 00						
July	5	4	Traveling expenses	13 75										
	8	8	Stores and supplies			59 68			117 65			1,883 53		
	5	13	Subsistence						39 60			580 00		
	5	14	Flour						66 00			620 00		
	5	18	Subsistence						48 65			981 24		
	5	23	do						1 00			50 00		
	7	27	Skiffs					202 50						
	9	33	Towage						400 00					
	3	34	Stone			380 55								
	8	35	Labor										8 20	
	10	36	Services										82 00	
	9	38	Supplies			2,210 90			49 25					
	14	41	Barge					1,250 00						
	18	50	Traveling expenses	7 25										
	14	53	Services										17 04	
	17	59	Supplies			16 74								
	17	60	Stone			270 27								
	13	61	Services										9 80	
	17	63	Plant					2,650 00						
	17	64	Labor and material			40 74				62 25			35 81	
	19	70	Transportation						10 10					
	25	77	Towage						450 00					
	27	90	Outfit					938 50						
	28	93	Flour						12 00			180 00		
	2	97	Traveling expenses	19 50										
	30	109	Subsistence									33 63		

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, *to October* 31, 1883, *both inclusive*—Continued.

LAKE PROVIDENCE REACH—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
July 30	117	Services	$75 00										
Aug. 1	120	Charter						$527 00					
2	124	Lumber					$11 75						
2	126	Services	50 00										
3	132	Stone			$921 71				$5 00			$12 60	
6	135	Traveling expenses	17 60										
6	136	Subsistence						19 80			$436 00		
6	137	......do						34 45			1,029 63		
6	138	......do						41 00			1,078 65		
6	139	Supplies			19 75								
7	141	Labor and material							421 75				
6	142	Skiffs					204 00						
9	154	Barges					6,900 00						
9	156	Labor and material			9 76				12 75				
10	166	Stone			156 78								
10	167	Labor										25 44	
13	170	Labor and material							94 60				
13	178	Traveling expenses	8 50										
15	187	Material							8 16				
15	190	Stone			393 43								
17	203	Labor and material							175 13				
17	204	......do							4 65				
17	205	Services										78 00	
27	213	Material			10 00								
27	217	Meters					82 50						
27	218	Labor							25				
27	226	Towage						8 00					
29	220	Skiffs, &c			17 03								
4	255	Traveling expenses	6 20										
4	257	......do	10 00										
4	259	......do	8 32										
4	262	Transportation						1 55					
31	274	Services	50 00										
31	276	......do	50 00										

Sept.	3	285	Charter						398 75					
	3	287	......do						527 00					
	3	292	Labor and material							12 65			9 20	
	1	296	Labor						3 75					
	1	297	Services	50 00										
	7	315	Subsistence						29 10			$560 51		
	7	316	Labor and material							356 00				
	7	318	Subsistence						43 15			783 37		
	7	320	Transportation						50					
	7	324	......do						38					
	4	327	Subsistence									42 50		
	10	331	Labor and material							182 00				
	4	339	Pay roll (De Paw)						189 00					
	12	340	Traveling expenses	5 00										
	12	343	Stone			204 75								
	12	344	Labor										10 96	
	12	346	Charter						90 00					
	13	350	Labor and material							18 82				
	13	354	Supplies			7 00			1 00					
	14	360	Charter						358 63					
	17	368	Subsistence									185 42		
	17	369	......do									1 53		
	17	370	Labor										2 80	
	17	373	Subsistence									38 63		
	18	378	Supplies			260 69								
	18	379	Traveling expenses	2 00										
	5	383	Stone			1,834 27								
	5	384	Labor and material							47 20			21 60	
	5	385	Towage						210 00					
	18	386	Labor						1 50					
	19	387	Labor and material							61 82				
	20	391	Supplies			6 18								
	20	392	......do			4 50								
	22	398	Labor and material							610 61				
	22	401	Labor, coaling						10 00					
	22	402	Subsistence									4 50		
	24	404	Labor and material							128 00				
	25	405	......do							42 70				
	25	412	Transportation						15 50					
	25	413	Services, pilot						58 33					
	3	418	Labor							1 00				
	30	424	Services	50 00										
	30	426	Charter						510 00					
	30	433	Subsistence									40 45		
	30	434	Charter						525 00					
	30	435	Labor and material							133 81				
	30	441	Charter						370 00					
	30	443	Labor and material							108 38				
	29	447	Services	50 00										
Oct.	9	6	......do							5 00				
	5	11	Stone			5,115 60								

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, *to October* 31, 1883, *both inclusive*—Continued.

LAKE PROVIDENCE REACH—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1883.													
Oct. 10	22	Stone			$786 26								
10	23	Towage						$150 00					
10	24	Services										$54 00	
22	34	Towage						6 00					
22	45	Labor and material							$351 61				
22	56	Coal				$694 00							
20	69	Labor							5 00				
25	97	Flour						36 00			$336 00		
29	105	Subsistence						55 10			1,060 11		
29	112	......do						1 90			166 70		
		Total	$2,038 66	$13 10	36,904 95	844 00	$148,108 24	13,685 87	2,815 98		27,246 98	627 42	$227,279 65

NEW ORLEANS REACH AND HARBOR.

Maj. Amos Stickney.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1882.													
....	187	Stationery		$1 00									
1883.													
Mar. 21	1	Steam launch					$8,000 00						
May 31	1	Services, inspector	$125 00										
June 30	2	......do	125 00										
May 31	3	Traveling expenses, inspector	1 60										
July 12	1	......do	5 00										
12	2	Services, inspector	41 67										
12	3	Traveling expenses, inspector	1 40										
18	4	Barges					14,274 40						
19	5	......do					2,000 00						
12	6	Tug					5,000 00						
25	7	Subsistence									$8 66		

	25	8	Towage						$10 00					
	2	9	Labor, coaling						10 00					
	27	10	Medical supplies			$3 50								
	27	11	Subsistence									68 76		
	27	12	......do									69 88		
	2	13	......do									15 00		
	2	14	Labor, coaling						4 00					
	2	15	Subsistence									6 40		
	30	16	......do									60 88		
	2	17	Labor, coaling						76 47					
Aug.	4	18	......do						6 00					
	4	19	Subsistence									7 50		
	4	20	Labor, coaling						7 50					
	4	21	Subsistence									6 65		
	4	22	......do									6 75		
	4	23	......do									2 80		
	17	24	Stationery		10 00									
	17	25	Supplies			9 60						244 22		
	27	26	Services										$6 00	
	29	27	Furnace repairs							$40 00				
	29	28	Repairs							14 00				
Sept.	4	29	......do							100 00				
	4	30	......do							5 30				
	13	31	Supplies			12 63			1 00					
	13	32	Capstans					150 00	8 00					
	18	33	Supplies			1,578 61			55 32					
	18	34	Anchors					36 57	3 18					
	5	35	Stone			300 96								
	5	36	Poles and transportation			30 00			60 00					
	5	37	Transportation						50 00					
	28	38	Labor in transportation						5 00					
	30	39	Wire			1,240 88								
Oct.	10	1	Stone			113 85								
	22	2	Towage						550 00					
			Total	299 67	11 00	3,290 03	$000 00	24,460 97	846 47	159 30	$000 00	497 45	6 00	$29,570 89

MOUTH OF RED RIVER.

Maj. Amos Stickney.

1883.														
June	8	1	Hulls					$2,000 00						
	18	2	Fire buckets					11 00						
	23	3	Superstructure and tables					1,623 65						
	23	4	Outfit					112 25						
	23	5	......do					29 64						
	23	6	......do					127 02						
	23	7	Anchors					10 22						

Itemized statement of expenditures for improving the Mississippi River, from December 1, 1882, to October 31, 1883, both inclusive—Continued.

MOUTH OF RED RIVER—Continued.

Date.	Voucher number.	For what expended.	Administration and inspection.	Office expenses.	Material and miscellaneous supplies.	Fuel.	Cost of plant.	Transportation and steamer expenses.	Repairs.	Labor on plant and construction.	Subsistence.	Care of public property.	Total.
1882.													
Jan. 23	8	Outfit					$284 12						
23	9	Furniture					92 60						
23	10	Services										$10 00	
23	11	Outfit					199 50						
25	12	Supplies			$2 78						$248 99		
25	13	do			2 78						248 91		
25	14	Subsistence									16 00		
25	15	do									16 00		
25	16	Material and supplies			125 74								
25	17	do			129 47								
25	18	Skiffs					84 00						
Aug. 17	1	Stationery		$10 00									
Sept. 30	2	Coal				$614 62							
4	3	Subsistence									31 60		
4	4	Labor, coaling						$23 90					
4	5	Subsistence									6 00		
4	6	do									12 00		
Oct. 22	1	Supplies			16 38			24 20			304 10		
22	2	Subsistence						1 80			32 00		
15	3	Labor, coaling						4 00					
15	4	do						10 75					
15	5	do						6 85					
15	6	do						10 87					
		Total	$000 00	10 00	277 15	614 62	4,524 00	82 37	$000 00	$000 00	910 60	10 00	$6,428 74

APPENDIX I.

REPORT OF CAPTAIN J. G. D. KNIGHT, CORPS OF ENGINEERS UPON OPERATIONS IN THE FIRST DISTRICT.

UNITED STATES ENGINEER OFFICE,
Cairo, Ill., November 27, 1883.

COLONEL: The following report is submitted in compliance with instructions of September 6, 1883, to send immediately after October 31, 1883, a report of work done by me with funds controlled by the Mississippi River Commission since the date of my last annual report and up to October 31, 1883.

It covers (1) levee location along the Saint Francis front; (2) the improvement of the New Madrid Reach; and (3) the improvement of the Plum Point Reach.

SAINT FRANCIS FRONT.

September 16, 1882, instructions were issued by the Commission that such surveys should be made of the Saint Francis front in the first district as would render it possible to report to the Commission the cost of closing all gaps in the levee to the old grade along that front; but no allotment out of which to pay the cost of such surveys was made until November 19, when $5,000 was allotted for the survey of so much of the Saint Francis front as lies in the first district. Two days later the Commission adopted instructions for the surveys of new levees.

As the old levee that could be utilized in the construction of the new amounted, in the first district, to but 1 per cent. of the volume of the entire work, instead of for closing gaps in the old levee, the required estimates were for virtually building a new levee along this front; hence, the instructions of the Commission as to surveys for new levees were decidedly applicable to this work.

In November a small party was sent out to commence the location; but as it was discovered that its instructions were not sufficiently comprehensive, and as fuller instructions necessitated a differently organized party, the first was recalled.

As the surveys and estimates could not be made in time for the last annual report, the survey was deferred until after the high water. In the spring, propositions were received from various parties to make the required surveys at prices varying from $15 to $100 per mile; and the lowest proposition, that of Civil Engineer H. N. Pharr, Lagrange, Ark., accepted. His party started out about June 1, 1883, from Bird's Point, Mo., and prosecuted the work with energy until it was stopped, in the bend above New Madrid, by high water. Resuming in July, Engineer Pharr carried on the location to its completion. The level notes and profiles were received in September; the end of October passed without the plotted location coming to hand.

As an approximate estimate the following figures are given, to be followed by a complete report when additional data are at hand:

Length of line to be leveed	miles	228.5
Length of line to be cleared	do	114.5
Volume of entire levee	cubic yards	9,000,000
Volume of old levee available	do	90,000
Volume of earth to be moved	do	8,910,000

Estimating earthwork at 25 cents per yard, clearing at $30 per acre—the number of acres being estimated as 750—and cost of surveying and inspection at $50,000, the approximate cost of leveeing so much of the Saint Francis front as is in the first district will be $2,301,000.

The amount expended under the allotment is as follows:

Survey party and draughtsman	$3,069 36
Instruments, stationery, and maps	226 05
Damage to crops	9 50
Mileage	8 00
Total	3,312 91

STATEMENT.

Allotment	$5,000 00
Expended as in above statement	3,312 91
Balance on hand November 1, 1883	1,687 09

As an alternate line is still to be run between Barfield and Mill Bayou, and as further examinations must be made with reference to the drainage of the swamp lands of Southeast Missouri and Northeast Arkansas, this balance will all be required for liabilities incurred or to be incurred.

NEW MADRID REACH.

The Commission recommended, August 18, 1882, that the district officer have a survey, with a view to improvement, made for the New Madrid Reach at next low water; and that he prepare and submit a project for the plant needed for this reach and one for the work of improvement. Later I was informed that the survey and plans called for of the New Madrid Reach should include the river from the head of Island No. 8 to the foot of Island No. 14, a distance of 60 miles. August 18, 1882, an allotment of $700,000 was made for the works on this reach.

The survey was commenced September 23, 1882, 1.5 miles above Island No. 8, and the field-work completed during the following December, having been carried to Gayoso, 2 miles below Island No. 14. A map of the entire survey was leisurely drawn later.

September 14, 1882, the following plant for this reach was recommended by the construction committee of the Commission and approved by the Commission: Twenty pile-drivers, forty deck-barges for stone and brush, one machine-shop boat, six quarter-boats, four two-hundred-foot mattress-boats, six one-hundred-foot mattress boats, six screen-boats, and forty skiffs.

December 19, 1882, while the construction of plant already ordered was continued, otherwise the allotment for this reach was suspended; and on March 16 $300,000 of this allotment was transferred to the Plum Point allotment, and the balance found to remain, after payment of all liabilities, ordered transferred to the Lake Providence allotment.

The plant ordered by and constructed for the executive officer of the construction department of the Commission is twenty-five pile-drivers, one machine-shop boat, and forty barges, as set forth in the following table:

List of floating property bought by the executive officer, Mississippi River Commission, out of allotment for New Madrid Reach, for use on that reach.

Description.	No.	First cost of each.	Total cost.	Remarks.
Barges	19	$1,850 00	$35,150 00	Of these barges, 17, costing $32,045, are in use on Plum Point Reach, and 23, valued at $42,100, in general towage service.
Do	5	1,849 00	9,245 00	
Do	10	1,800 00	18,000 00	
Do	5	1,950 00	9,750 00	
Do	1	2,000 00	2,000 00	
Machine-shop boat*	1	8,130 00	8,130 00	In use at Plum Point.
Pile-drivers	20	5,325 88	106,517 60	5 in use at Plum Point; 5 in use at Lake Providence; 10 laid up.
Anchors	......	....	1,630 48	
Outfit	......	....	227 45	
Total	......	....	192,850 53	

*The cost of the machine-shop boat, without tool outfit, was $3,380.

The expenditures under the original allotment are as follows:

	Captain Sears.	Captain Knight.	Total.
General administration	$632 92	....	$632 92
Office expense	21 00	....	21 00
Care of property	18 50	....	18 50
Cost of plant	193,549 99	....	193,549 99
Steamers, towage, &c	6,496 50	....	6,496 50
Surveys	....	$4,498 95	4,498 95
Labor on plant	20 00	....	20 00
Miscellaneous	3,833 25	....	3,833 25
Total	204,572 16	4,498 95	209,071 11

STATEMENT.

Allotment		$700,000 00
Transferred to Plum Point allotment	$300,000 00	
Transferred to Lake Providence allotment	187,500 00	
Disbursed by Captain Sears	204,572 16	
Disbursed by Captain Knight	4,498 95	
		696,571 11
Balance		3,428 89
Balance in hands of Captain Sears November 1		$2,427 84
Balance in hands of Captain Knight November 1		1,001 05
		3,428 89

Though apparently it is not contemplated to begin work on the New Madrid Reach with any portion of the appropriations hitherto made, the still existing necessity of the improvement of this reach cannot be doubted. During the low-water season just passed it has been marked by three of the most troublesome places between Cairo and Memphis, viz: Phillip's Crossing, Point Pleasant, and Tiptonville. Shoal water and tortuous channel have characterized these places, and the latter vicinity has been marked by loss of property, delay of steamboats, and many channel changes. It will continue to be so characterized until the extremely unstable banks from New Madrid to Tiptonville be protected from the assaults of the river, and the channel otherwise fixed. The locality is an excellent one for a crucial test of any system of bank protection, much of the river bank being sandy and high.

Should the Commission consider the advisability of work of river improvement elsewhere than where already commenced, I would suggest this field as one where improvement is urgently demanded.

PLUM POINT REACH.

From December 19, 1882, to June 6, 1883, First Lieut. T. W. Symons, Corps of Engineers, was in local charge of work on this reach. On his accepting other duty, United States Assistant Engineer A. J. Frith resumed charge, and has since retained it.

Since the date of my last report, additional dikes, shown on the maps of the reach annexed (Plates II–V), and as follows, have been ordered by the Commission: Two dikes 1*a* and 1*b*, between dikes 1 and 2, at Gold Dust; dike 4, in Osceola Chute, and dike 2, in Bullerton Chute.

The dikes in course of construction at that date were those at Gold Dust—the main dike and cross-dikes 1 to 5—the Osceola middle, and Osceola-Bullerton. Later work on the upper Osceola was resumed. Osceola cross No. 1 was commenced March, 1883; Osceola cross No. 2, April, 1883; Osceola cross No. 3, March, 1883; Bullerton cross-dike No 1, June, 1883; Plum Point main dike and No. 1 cross-dike in September, 1883, and No. 2 cross-dike in October.

Of the dikes ordered or approved by the Commission, the following have not been commenced: Osceola cross No. 4, Bullerton cross No. 2, and Plum Point cross Nos. 3, 4, and 5. Osceola cross-dike No. 4 was ordered June 30, 1883, but its construction could not be carried on at low water. Bullerton cross-dike No. 2, ordered at the same time, could not be put in, as the attempt so to do would have interfered with the use of the only navigable channel near Bullerton Tow-head; the Plum Point dikes were deferred, as my project, in which they were incorporated, was approved subject to the proviso that they be not undertaken so long as the plant can be employed elsewhere. While projects submitted from time to time covered bank protection of the Tennessee shore from Ashport to Gold Dust, of the Arkansas shore from Mill Bayou to upper Osceola Chute, and from Bullerton Chute to Craighead Point, of upper and lower Osceola Bars, of Bullerton Tow-head, and Yankee Bar, to attempt to protect more than Bullerton tow-head has been found impracticable. That this should be protected was necessary, as the bar in front continually crowded the water over, thus threatening the cutting in two of the tow-head; also as the river persisted in establishing for this season the main channel in Bullerton Chute, there might have been much wearing away at the head. Two thousand six hundred and ninety-four feet of mattress, without upper bank protection, were built at Ashport, and so far have served to prevent caving.

The following table shows the amount of work reported at each place and the amount of dike actually standing, as shown by the reports of Assistants Geuder, Marx, Nolty, and Yeager (Appendices J 2–J 5) and the plates thereto annexed (Plates II–V). The difference between the two items serves as a basis for determining the total amount of work destroyed, not limited to the past year, and the estimated value thereof. These values are based on those given later in a table, showing the amount and cost of all work on this reach:

Estimated value and quantity of damage done to works at Plum Point, Tennessee.

Construction at—	Pile-work, in linear feet.			Brush-work, in squares of 100 square feet.			Approximate value.
	Reported as constructed.	Reported as standing.	Number of feet lost.	Reported as constructed.	Estimated quantity intact.	Estimated quantity lost.	
Plum Point dikes	901	901		814.80	814.80		
Bullerton:							
Tow-head bank protection				20,554.80	17,392.80	3 162.00	$24,850
Main dike	3,305	4,850	3,455	3,154.50	1,843.50	1,311.00	38,000
Cross dike	1,770	1,770		2,520.35	2,520.35		
Osceola:							
Upper bar bank protection				4,125.30	2,980.30	1,145.00	7,400
Lower bar bank protection				8,054.84	7,238.00	816.84	5,200
Upper dike	2,815	2,268	547	3,867.17	3,115.00	752.17	3,550
Middle dike	3,773	1,059	2,714	5,292.80	3,409.00	1,883.80	32,500
Cross dikes	6,987	4,570	2,417	3,620.06	2,718.29	901.77	28,200
Gold Dust dike	35,083	22,397	12,686	17,670.00	11,281.00	6,389.00	147,400
Ashport bank revetment				4,041.00	4,041.00		
Bullerton Tow-head bank protection	*2,400		2,400	*540.00		540.00	15,000
Osceola upper dike	*4,500		4,500	*570.00		570.00	
							302,100

NOTE.—The amount of brush-work reported as lost includes, in the case of dike work, such amount of mattress as had to be renewed on account of pile-dike giving way. Figures marked * represent work done previous to July 12, 1882, *i. e.*, previous to present appropriation.

The damage to the pile-work resulted from the weak forms of dike first used, from its incomplete condition, and from irresistible scouring action of the river.

The first work consisted of bents formed by pulling over and fastening at the tops corresponding piles of two parallel rows; 2,400 feet of this was removed by scour in the absence of a foot-mat. Later, dikes of piles braced by single inclined piles and longitudinal stringers were tried and found wanting; the one at Upper Osceola Chute having been almost wholly broken off, though not before it had induced much deposit at the head of the chute. Then was tried a form shown in my report of 1882, still weak, as was shown by its experience with the high water of last spring. A standard, planned by United States Assistant Engineer A. J. Frith, has been adopted for the present, and will, it is thought, prove sufficiently strong.

Apart from the dikes, even if finished, being too weak to resist the great strains to which they have been subjected, there was the desire to take advantage of favorable stages of water, which resulted in the pile-work being hurried ahead too far in advance of its protecting mat-work; and when rising water came, there came with it masses of drift, which, at the same time, both prevented mat construction and induced scour. Finally 2,500 of the 3,300 feet of Osceola middle dike were carried away by the river suddenly scouring out a volume having a cross-section of 1,200 feet width and 20 depth. Even the foot-mat along its front failed to stay this scouring action.

Damage to the bank protection has resulted from three causes: Chiefly, the attempt to work at too high stages of the river, in consequence of which the mattress or low-water protection has, by rising water, been carried to the tops of banks and there grounded so high as to admit of undermining; secondarily, water seeping from accumulations in pools and above comparatively impermeable strata has induced caving in rear of high-water protection; and in a very few cases the mattress or its moorings have been found too weak to bear the strain brought upon them by rapid currents.

The question is naturally suggested, is a repetition of this great damage to be expected?

As to pile-work, the answer is, no. The height of the tops of dikes having been lowered, less drift will accumulate against the dikes. A careful following up of pile-work with brush-work and mattressing of openings before closing them will diminish the possibility of scour. The increased strength given to dikes will increase their resistance, and equally beneficial results may be expected from a reliance on cross-dikes, in some cases where longitudinal have been used, as in the case of Osceola middle dike. Damage to this was exceptional in its cause, and how to guard against like injury is not yet known.

As to bank protection, loss may be avoided by abstaining from efforts to build a low-water protection during high stages, as then such work could only be done with any hope of success along a bluff shore. Mattresses can also be strengthened to stand any currents so far experienced. Seepage water is more troublesome. Drainage of pools may be attempted in favorable cases; but more likely the true remedy is an exceedingly flat slope above the line of exudation.

The following table gives, as nearly as it can be made from data in this office, the amount and cost of all work on this reach. The exceptionally high cost of Bullerton cross-dike No. 1 is due to deep and rapid water; that of the Plum Point dikes, possibly, to the fact that much work thereon, being incomplete, can only be estimated.

Construction of—	Labor in construction.	Material for construction.	Subsistence.	Repair and outfit of plant.	Care of property.	Steamer and towage.
Plum Point dikes	$5,167 26	$5,416 11	$1,078 80	$7,954 00	$1,166 22	$3,615 28
Bullerton:						
Cross dikes	13,537 38	9,497 35	3,179 70	17,878 00	2,621 44	8,126 46
Main dikes	19,859 59	15,876 60	5,371 50	28,036 00	4,110 77	12,743 88
Towhead bank protection.	32,766 69	30,427 86	7,890 80	48,480 00	7,108 54	22,036 42
Osceola:						
Lower bar bank protection	11,392 98	8,504 86	2,940 00	15,576 00	2,288 84	7,079 82
Upper bar bank protection	5,318 27	4,961 00	1,604 10	8,104 00	1,188 34	3,683 85
Upper dike	9,487 90	9,850 63	2,234 80	14,674 00	2,152 34	6,670 00
Middle dike	10,260 52	8,955 10	2,406 90	14,740 00	2,162 25	6,708 00
Cross dikes	17,866 67	14,376 00	4,611 60	25,134 00	3,685 43	11,424 83
Gold Dust dikes	85,280 05	70,680 53	18,019 50	128,992 94	18,013 65	55,460 46
Ashport bank protection	5,187 06	5,527 27	1,402 20	8,268 00	1,211 65	3,758 85
Totals	216,074 31	193,073 31	50,740 50	317,836 94	45,704 47	141,301 85

Construction of—	General administration and office expense.	Survey.	Miscellaneous.	Total cost.	Total constructed.	Approximate price.
Plum Point dikes	$615 80	$397 70	$360 00	$25,771 17	*1,551 feet	$16.65 p. ft.
Bullerton:						
Cross dikes	1,384 80	893 90	855 00	57,978 53	1,770 feet	$32.75 p. ft.
Main dikes	2,170 50	1,401 80	1,290 00	90,860 14	8,305 feet	$11 p. ft.
Towhead bank protection.	3,753 80	2,424 00	2,200 00	157,087 61	21,095 □	$7.85 p. □
Osceola:						
Lower bar bank protection	1,205 90	778 80	780 00	50,542 75	8,055 □	$6.30 p. □
Upper bar bank protection	627 80	405 20	360 00	26,252 06	4,125 □	$6.40 p. □
Upper dike	1,136 80	733 70	650 00	47,539 67	7,315 feet	$6.50 p. ft.
Middle dike	1,141 30	737 00	650 00	47,756 07	3,773 feet	$12.66 p. ft.
Cross dikes	1,947 00	1,256 70	1,050 00	81,352 23	6,987 feet	$11.66 p. ft.
Gold Dust dikes	9,739 84	6,264 36	5,173 48	406,624 81	35,083 feet	$11.60 p. ft.
Ashport bank protection	639 80	413 40	370 00	26,777 72	4,041 □	$6.65 p. □
Totals	24,361 34	15,706 56	13,738 48	1,018,537 76		

* Of the 1,551 feet marked *, 1,500 were incomplete, and are estimated as 750 feet completed.

NOTE.—The sign □ means squares of 100 square feet.

Methods of purchase and transfer of plant, paid for out of the first appropriation especially, have made it impossible to distinguish between repair, outfit, and construction of plant. The amounts in the column headed "Repair and outfit of plant" are determined by deducting from all payments for plant such amounts as appear in another table as "Approximate first cost of plant."

The reports of the assistants annexed (Appendices J 1 to J 7) describe in detail the work done. By no means the least important report is that of United States Assistant Engineer W. H. Powless, in charge of surveys, to which is attached two sheets showing the part of the reach under improvement, hydrographs of 1882 and 1883, and one sheet showing a comparison of areas of sections, mean depths, and profiles (Plates I, VIII, and IX). Methods of administration and of construction, and a partial description of plant, are set forth in the report of Assistant A. J. Frith (Appendix J 1, and Plates VI and VII), and a description of one of the hydraulic graders, with cost of work and forms used in collating information by which to determine this cost and the efficiency, is set forth in the report of Assistant S. P. Hatfield. (Appendix J 6.) To all of the assistants credit is due for energy and judgment displayed under conditions at times far from encouraging, and especially is it due to Assistants Frith, Powless, Gender, Nolty, and Marx. The plant has at all times been kept or promptly placed in good condition by Master Carpenter Henry Adkins and Master Mechanic P. B. Sexton.

I am also instructed to report upon the results of work so far done, and in so doing I am guided chiefly by a study of comparative sections, which, though not attached to this report, have served as a basis for the sheet relating to sections and profiles attached to Assistant Powless's report (Plate IX). These sections were measured December, 1882, to February, 1883, and September to October, 1883; the stages of the river during these months are shown on the hydrographs (Plate VIII). During the former, the river rapidly rose from nearly its lowest to its highest stage, and during the latter months it was essentially at a low stage. The high water only affected the comparisons of sections 17 to 35, and these but slightly, if at all, as the rise was from the Ohio, comparatively free from silt, and had not more than set in before the completion of the survey. During the low water of 1882 the river was not gauged; therefore, no comparisons of river discharge can be made.

From a summary presented in Assistant Powless's reports, it will be seen that between the periods of the low waters of 1882 and 1883 there has been a decrease of 0.9 foot, or 6 per cent., in low-water mean depth, one of 4,728 square feet, or 9.5 per cent., in low-water mean sectional area, and of 109 square feet, or 3.3 per cent., in low-water mean sectional width. These are doubtless the results of the three high-water stages of last spring. The volume of fill below ordinary high-water mark is nearly three times that of scour; below low-water mark the fill is 4.6 times that of scour. It will be seen, however, that the low-water channel depths are greater this season than last in the following vicinities: Ranges 33, 34, and 35, outside and about the middle of Elmot Bar; Range 43, opposite the middle entrance to Osceola Chute; Ranges 48 and 49, in the crossing from Plum Point to Bullerton Chute; Range 53, at the foot of Bullerton Chute; Ranges 58, 59, and 60, at the head of Yankee Bar, and Ranges 63, 64, 65, and 66, on the upper side of Craighead Point. The locality of chief interest is that of the crossing from Plum Point to Bullerton Towhead. I am informed that in past years this has been the troublesome place of the Plum Point Reach. Certainly there has here been an increase of channel depth of from 7 to 9 feet, which is probably due to the contraction produced by the upper and lower sections of the Osceola-Bullerton dike. It is true that an effort was made to join these sections. Had this effort met with success, it is believed that diverting a large portion of so large a body of water as that going through Bullerton Chute would not have failed to give results at this crossing equally good with those obtained. In front of Bullerton Towhead there has been rather a redistribution of material than an increase of effective low-water area; but this redistribution has been such that the deeper water is found to coincide with the desired new channel. When the Plum Point system of dikes is more nearly completed, I can see no reason for doubting that there will be a channel of at least ten feet at low water in front of this towhead.

Immediately behind the Gold Dust main dike the bar crest has raised 10 feet, ranging from 12 to 25 feet above the level of the low water of 1879; the latter figure is reached on the first range above Elmot Bar, No. 31. The fill runs out to nothing about 600 feet in rear of the dike.

Consideration of the results gained is rather premature. Over the greater portion of the reach the works are in too incomplete a state to be judged by results. Such judgment should be deferred at least until dikes in course of construction are completed, and the Arkansas shore from Mill Bayou to Osceola Chute, Osceola Bars, and Bullerton Towhead are revetted.

Below are given the works so far planned and still unexecuted, and an estimate of the cost of their completion:

Ashport revetment, 19,600 feet, at $12	$235,200 00
Fletcher's revetment, 23,520 feet, at $12	282,240 00
Osceola Bars revetment, 13,720 feet, at $12	164,640 00
Yankee Bar revetment, 7,840 feet, at $12	94,080 00
Craighead Point revetment, 15,000 feet, at $12	180,000 00
Gold Dust dikes, 10,300 feet, at $12.25	126,175 00
Plum Point dikes, 19,250 feet, at $12	231,000 00
Osceola No. 3 dike, 1,000 feet, at $12.25	12,250 00
Bullerton No. 1 dike, 700 feet, $34.50	24,150 00
Bullerton No. 2 dike, 1,000 feet, at $25	25,000 00
	1,374,735 00

The approximate first cost of plant now employed at Plum Point is as follows:

32 barges		$48,000 00
16 quarter-boats		58,320 00
8 mattress-boats		43,310 00
Derrick-boat No. 1		5,200 00
Derrick-boat No. 2		4,700 00
2 hydraulic graders		60,464 00
14 pile-drivers		62,300 00
2 pile-drivers		10,640 00
2 pile-drivers		9,240 00
6 Whitehall boats		339 00
22 skiffs		536 50
29 skiffs		580 00
12 skiffs		300 00
1 steamboat		11,740 00
1 steam-tug		9,500 00
1 steam-launch (sunk)		3,200 00
1 steam-launch		1,500 00
Paid from Plum Point allotment		329,869 50
1 machine-shop boat	$8,200 00	
5 pile-drivers	26,625 00	
18 barges	34,045 00	
Paid from New Madrid allotment		68,870 00
		398,739 50

STATEMENT.

Allotment from appropriation of March 3, 1881	$500,226 67
Allotment from appropriation of August 2, 1882	1,000,000 00
	1,500,226 67

Disbursed by Captain Quinn	$420,163 58	
Disbursed by Captain Sears	298,866 96	
Disbursed by Captain Knight	619,323 24	
Total disbursements to November 1, 1883		$1,338,353 78
Balance on hand November 1, 1883		161,872 89

This balance is accounted for as follows:

In the United States Treasury	$31,000 00
In the hands of Captain Sears	25,365 15
In the hands of Captain Knight	105,507 74
	161,872 89

The third of these balances had been reduced by November 26, 1883, to the following amount, $51,180.51.

SUMMARY.

The following table shows all expenditures made for the first district Mississippi River up to November 1, and also includes $22,319.45 of liabilities incurred:

Expended by—	General administration.	Office expenses.	Care of property.	Construction of plant.	Steamer towage.	Survey.	Labor on plant.	Labor on construction.	Material for construction.	Quarters.	Miscellaneous.	Subsistence.
PLUM POINT.												
Capts. Knight and Quinn	$8,544 76	$12,648 61	$44,969 97	$269,988 70	$110,665 34	$15,616 56	$128,808 45	$208,832 70	$122,560 64	$32,248 57	$13,738 48	$93,093 49
Capt. C. B. Sears	2,827 92	340 05	734 50	125,784 16	47,376 51	90 00	5,980 84	7,241 61	70,512 67			88,028 70
	11,372 68	12,988 66	45,704 47	395,772 86	158,041 85	15,706 56	134,829 29	216,074 31	193,073 31	32,248 57	13,738 48	181,122 19
NEW MADRID.												
Capt. J. G. D. Knight						4,498 95						
Capt. C. B. Sears	632 92	21 00	18 50	193,549 99	6,496 50		20 00				3,833 25	
	632 92	21 00	18 50	193,549 99	6,496 50	4,498 95	20 00				3,833 25	
SAINT FRANCIS.												
Capt. J. G. D. Knight						3,312 91						
Capt. C. B. Sears												
						3,312 91						

RECAPITULATION.

Plum Point	$11,372 68	$12,988 66	$45,704 47	$395,772 86	$158,041 85	$15,706 56	$134,829 29	$216,074 31	$193,073 31	$32,248 57	$13,738 48	$181,122 19
New Madrid	632 92	21 00	18 50	193,549 99	6,496 50	4,498 95	20 00				3,833 25	
Saint Francis						3,312 91						
	12,005 60	13,009 66	45,722 97	589,322 85	164,538 35	23,518 42	134,849 29	216,074 31	193,073 31	32,248 57	17,571,73	181,122 19

Total to October 31, 1888 .... $1,573,057 25

Very respectfully,

JOHN G. D. KNIGHT,
Captain of Engineers.

Lieut. Col. C. B. COMSTOCK,
Corps of Engineers, U. S. A.,
President Mississippi River Commission.

I 1.

REPORT OF ARTHUR J. FRITH, ASSISTANT ENGINEER, UPON OPERATIONS ON THE PLUM POINT REACH.

UNITED STATES ENGINEER OFFICE,
Elmot, Ark., November 5, 1883.

CAPTAIN: I respectfully submit herewith a report upon the administration of the work under my immediate charge during the past year—the plant used, methods of construction employed, and methods of quartering and subsisting the employés.

Previous to the removal of your office to Cairo, I acted as executive engineer in charge of construction under your immediate supervision, and fulfilled like duties for Lieut. Thomas W. Symons, Corps of Engineers, while he was in charge of operations at Plum Point, from January to June, 1883. Since his departure I have had immediate supervision of all work of construction and repairs relative to the improvement of this reach. I have been ably assisted by the assistant engineers in local charge of various sections of the work. Their duties have been as follows:

All surveys and gauging observations and the preparation of all maps and tables of results made during the year have been conducted by Assistant Engineer W. H. Powless and party.

In charge of mattresses and pile dikes at Gold Dust, Assistant Engineer George W. Gender, assisted by Messrs. W. L. Seddon and W. A. Gould.

In charge of mattresses and pile dikes at Plum Point and in Bullerton Chute, Assistant Engineer F. A. Yeager.

In charge of mattresses and pile dikes upon Osceola Bar and in Osceola Chutes, Assistant Engineer Charles D. Marx.

In charge of mattressing of Bullerton Towhead, Assistant Engineer Aug. J. Nolty, while Assistant Engineer S. P. Hatfield has had charge of Grader No. 4 and its operations at various localities.

To keep strict supervision on field operations, these gentlemen have had, for pile, driving, fleet foremen, directing the foremen of pile-drivers, and for mattress work, one head foreman, and from one to three sub-foremen, as found necessary.

The care of quarters, property, and clerical work is intrusted to a boarding master on each large quarter boat, under the supervision of an assistant engineer.

Daily reports from each pile-driver, showing depth of water, number of piles driven, number of riders erected, piles, drift-bolts, and staples used, are received by each assistant in charge of dike construction, and all assistants submit to this office ten-day reports of progress, material received, subsistence, and delays and difficulties encountered.

Repairs of plant are in charge of a master mechanic and a master carpenter, who, with their forces, are stationed at headquarters, as are all the necessary clerks and commissary.

PLANT.

For the prosecution of the work we have had: 3 tow-boats, 1 steam launch, 1 machine-shop boat, 2 derrick boats, 23 pile-drivers, 9 mattress boats, 50 barges, 1 coal flat, 16 quarter boats.

Pile-drivers.—All drivers furnished are designed to sink the piles with a hydraulic jet, assisted by a heavy hammer, when stiff soil or unyielding material is encountered. Of these there are two kinds.

First. Drivers with 30 feet leads, which are those originally built on the works for driving both straight and inclined piles. These have been altered so far as permanently fixing the leads for straight driving, stiffening the leads, etc.

Second. Those with 35 and 45 feet leads arranged to drive over the side. These include all those furnished during the past year, upon which few alterations have been made, except bracing and stiffening the leads and frames. This form has proved more convenient than No. 1, especially those with high leads, and carrying heavy double pumps, with 12×10 inches steam cylinder, 6×10 inches water cylinder, and delivering water at 60 pounds' pressure at the nozzle and 90 pounds at the pump. They give greater progress in the heavy clay and gravel encountered. The lighter pumps, capable of delivering 300 gallons per minute at moderate pressure, are efficient in ordinary soils; but as the resistance to driving increases, the use of the 2,000-pound hammer becomes imperative. All drivers are provided with these hammers, raised by a permanent line, by which light and rapid blows are delivered, and their employment is necessary to penetrate mattresses and many strata that are encountered. Experience with the jet has developed the belief that 1½ to 2 inches diameter is more efficient than the smaller size.

From twenty to twenty-three piles a day have been driven under favorable circumstances; but when deep water, varying strata, moving braces, fastening, and other delays are encountered, twelve piles is a fair day's average.

These drivers are capable of being employed in 45 feet of water and considerable current, but efficient driving is difficult in water over 30 feet in depth and in violent currents.

Mattress boats.—At the commencement of the year we had in all six mattress boats:

Two 212 feet in length for 200-foot mattresses.

Three 100 feet in length for 100-foot mattresses.

One 175 feet in length for 150-foot mattresses.

Of these, two are designed for mattresses with a wire base; the others for mattresses woven on poles. We have since received three boats 160 feet in length, also for pole mattresses. The design of these boats is not exactly similar but experience has taught that the main requisites for the pole mattress are an ample platform on the lower side; ways with a slope of 1 foot in 3½ feet running close to the water, but not too far over the edge of the barge, also capstans at the ends for ready handling, and a liberal number of chocks and kevels for fastening lines.

Quarter-boats.—There are now in service twelve quarter-boats, including that used as office and headquarters, and one for storing supplies. At the commencement a frame building on an ordinary brush barge fulfilled all requirements, but the inconveniences and discomforts of this form led to the building of the type now in use, and in which it was endeavored to combine all that is necessary for the health, comfort, and safety of the employés. Most of these boats were built upon the works, and consist of a sound coal barge, the hull of which is used for kitchen, stores, and dining-room, the upper works containing rooms for assistant in charge and foreman, and sleeping quarters for the men. These boats are provided with life line and floats, and buckets and water-barrels to be used in case of fire, and accommodate 124 in all, including officers, cooks, and men.

Graders.—Two hydraulic graders, No. 2 and 4, have been allotted to work on this reach.

No. 2, during the fore part of the year, was in use at Memphis, and was later held in reserve until on September 26, when about to be used in Elmot Chute, it was sunk and disabled. It has since been raised, and is now in progress of repair.

No. 4 has, except during the high water, been in almost constant use during the year, the work done, being highly efficient and satisfactory.

These graders are each fitted with three boilers 22 feet long by 40 inches diameter of shell, double compound condensing pumps with 18 and 36 inch by 24 inch steam cylinders, and 16 by 24 inch water cylinders, and deliver 2,000 gallons a minute into an iron pipe boom, reaching up the bank, and from which lead the hose to the various working nozzles. Two 1½ and one 1¾ inch nozzles are ordinarily used, with pump pressure of 110 pounds and nozzle pressure of 80 pounds, the efficiency of water cylinder being almost 80 per cent. The woven cotton hose has proved in use, the most reliable. One grader has removed from 1,800 to 4,000 cubic yards of earth per day, at an average cost of 2.98 cents a yard, including wages, coal, subsistence, &c. Each grader is provided with electric lights for night work.

Barges.—To supply material to various parties there are used fifty barges, 100 by 25 feet, and one smaller barge, used for coal. Many of these, constructed with a view to carrying light brush, have broken down under the heavy willows generally furnished. Those received later in the year and others altered here are better proportioned, having 6-foot gunwales and two 4-inch fore-and-aft bulkheads, heavy headblocks and bits, and carry 150 cords of brush or 200 cubic yards of rock. There are among the general-service barges some 30 by 120 foot barges carrying 330 cubic yards of rock. These are, however, difficult to handle in heavy currents when sinking mattresses.

METHODS OF CONSTRUCTION.

Pile dikes.—The dimensions of piling used during the year were increased over those previously accepted, by increasing the least size at the top to 8 inches from 6, the maximum limit at the foot being 18 inches. Cottonwood piles form the bulk of the material used, though considerable cypress has been received. The piling was received in rafts landed at points above the localities where each piece of work was in progress, and, when practicable, dropped in small sections to the drivers; if not, the derrick boat loaded 100 to 140 of them on barges which were towed to convenient localities for sorting and distribution.

The cross-section of dikes used in the early months of the year is shown in Plate VI, Fig. 1, with spacing of 7½ feet between each truss. As a considerable portion of this dike was destroyed, with your permission I undertook an investigation to determine a form of dike which should combine an equality of resistance coupled with economy of material and a liberal factor of safety, and of proportions that could be maintained in all depths of water. The difficulty of determining exact data for these calculations throws some ambiguity into the whole subject; still it is believed that the form chosen and since used is the best that our facilities allow, and since low figures were taken on doubtful points, can be relied upon to withstand the destroying forces of the river.

Much of the dike work now in place was constructed before a satisfactory form was adopted, but the design used since about May, 1883, is that shown in Plate VI, Figs. 3 and 4, in which the width equals twice the height of the dike. Up to 10 feet in height a single row of piles is used; from 10 to 20 feet, the form shown in Figs. 3 and 4 with a single pile in front rows; from 20 to 30 feet, a cluster of two piles is used in front row; from 30 to 40 feet, a cluster of three piles; from 40 to 45 feet, a cluster of four piles, each pile in the cluster having its own cable. After 35 feet, double or treble piles are used in middle and back rows.

The entire dike is cross-braced on top to prevent any racking motion while under strain, and the intersections of piles and riders are well wired and drift-bolted. The cables used contain six strands of No. 8 wire or eighteen strands of No. 12, and have a large factor of safety to resist deterioration. By varying the spacing, any degree of strength can be obtained. The spacing used has varied between 6 and 9 feet. This design is calculated to balance, in varying depths of water, the tendency to complete overturning of the dike, to destruction of each member by direct strain ,and to the central breaking of the front pile by the pressure of the water. It will probably be found advisable in future construction to replace the wire cables by iron tie rods, with some means for quick and easy coupling of the short rods to suit the varying lengths desired.

The soft, permeable and unstable soil in which the dikes are driven is one of the main causes of their failure, and one of the most difficult obstacles to guard against. Heavy mattressing of the foot of the dike seems to be alone capable of obviating this; but with the horizontal mattresses used during the first months of the year, instances have occurred in which the current has passed completely under them; hence the grillage mattress, formed of two layers of brush at right angles, held together by a frame of poles wired through and through, the whole being sunk between the rows of piling, and the footmats in front of the dikes, have not lately been sunk flat upon the bottom, but are arranged as shown in Fig. 3, A being the grillage, and C the tipped mattress, which takes the place of the footmat in all but main dikes. Very good results were obtained with grillage thus arranged at Gold Dust this spring. The tipped matress, which is in part a curtain, has been made from 30 to 100 feet wide, and from 100 to 150 feet long, the inclined portion being supported on piling or heavy poles. This form has a tendency to throw the current upwards, thus inducing at first a deposit in the angle B which will, it is believed, increase in a manner similar to sand waves. It has the further advantage of following up a scour with all the force of the impinging current, while the tipped grillage in the rear prevents a destructive action of the induced eddy.

To avoid the destroying action of drift, experienced with portions of dikes driven at high water, dikes are now built up to the 15-foot stage, rising to 25 feet as they approach the shores, which are guarded against scour by thorough mattressing at the extremities of the dike (Fig. 4). On high dikes, an immense accumulation of drift occurs at high water, which rendered all work at this stage during last spring extremely difficult and unsatisfactory.

For operations at this stage an extra row of piles should be driven in front of the dike to hold back the drift until mattresses, &c., are completed, after which it may disappear or not, as in the design it is not considered as part of the dike. In the destructive action of drift it is not so much the actual pressure which is to be feared, as this is much less than is generally believed, but that the accumulation of floating material contracts the section of discharge and causes a scour below equal to its own depth, and thus tends to destroy the structure. If this scour can be guarded against the drift offers a great and useful resistance to the current, and in the case of Osceola cross-dike, No. 1 (Fig. 2), where the drift is 600 feet wide by 1,200 feet long, the current in the chute almost entirely ceased merely from resistance to the flow of water offered by the lower surface of the drift, and has caused a heavy deposit both above and below it, while the pressure against the dike cannot be greater than that of a head of water equal to the total high-water fall of the chute. The drift is 10 feet thick at the dike, rising to nothing on outer edge, and has scoured out the soil beneath, an amount equal to its own thickness. This dike suggests a useful employment of a very troublesome material, especially in localities where the depth at high stages of the river is not such as to totally prevent piles being driven, and may be the most efficient form of obstruction for high-water dikes.

Mattresses.—The willow brush has been furnished by contract, and has been accepted from 2 to 5 inches at the butt and forty feet long. The contractors furnish it loaded on barges at their various camps from whence we tow it to the parties needing it. Rainy weather and the soft condition of the localities where it is obtained have kept the supply of brush almost constantly below the requirements, from which trouble and delay have been suffered throughout the year.

Several methods of constructing mattresses have been followed, governed by their localities and the work they were expected to perform.

They may be classified as follows:

1st. Shore mattress for the protection of the banks.
2d. Revetment, or protection of high-water slopes.
3d. Foot mattress, for protection of dikes.
4th. Tipped mattress.
5th. Grillage mattress.

1st. Shore mattresses for the protection of caving banks have been made in widths varying from 100 to 150 feet and lengths governed by the difficulties in sinking. When no particular danger is to be anticipated, this mattress may be continuous to almost any length. Two varieties have been in use: 1st, that used by Major Ernst below Saint Louis, where the willows are woven on poles, preferably of sycamore, 7 to 8 feet apart, Plate VII, Fig. 5, and forming a stiff and strong mattress, of which 170 feet a day have been made with light brush and under favorable circumstances. This mattress is easy of construction and has been mostly used during the year.

2d. There has also been used along the face of Bullerton a 100-foot mattress woven on a wire base, the willows being interlaced, as shown in Plate VII, Fig. 6, forming a mattress which is extremely pliable and hence more easily sunk. It is not so easily constructed as the first, but a slightly greater average length a day has been obtained.

The majority of brush furnished lately has, unfortunately, been too large and heavy to obtain the best results.

As the shore mattresses are made they are guyed to the shore by 1½ to 2 inch lines, which are removed as they are sunk.

The mattresses are fastened to the shore by wire cables or wires at frequent intervals and, when necessary, piles have been driven through the mattress to prevent any movement.

When a stretch of mattress 1,000 or more feet in length is to be sunk, great care must be used. In light currents the most rapid and easiest method (Plate VII, Fig. 7) is to commence sinking at the head, keeping the inner side of the mattress sunk a little in advance, and carefully sounding to see that it does not rise after the force of the current is removed. It will be perceived that the weak point is in the corner (A) where the sharp bend tends to break the poles or willows, and where there is nothing to resist the downward pull of the current but the flotation of the mattress.

When the water is very rapid it has been our practice to commence sinking at the lower end (Plate VII, Fig. 8) where the shore side is also kept sunk a little ahead. This necessitates the drawing of stone barges up stream, which even in the slack-water behind the mattress is troublesome and takes much time; still it has proved much the safer method, as there is little chance of sharp bends and broken willows or the loss by collapsing of an entire mattress from a single accident. It is believed that with this method, when the mattress is made sufficiently strong, especially on the outer edge, and has been sufficiently guyed, that a collapse or entire loss is simply impossible. In October, 1883, on Bullerton 1,800 feet of mattress were sunk in 40 feet of water with a five-mile current. This mattress was built on a netting formed of wire cables such as were used on the dikes; still, at first, it proved too light and broke, yet but 75 running feet were lost. It was then strengthened until we had three cables on the outer edge and extra poles and wire on the outer 50 feet, when it was sunk in place in perfect shape without difficulty.

We have been extremely fortunate in sinking, and except when a mattress was torn bodily from its fastenings by drift at high water, but very little has been lost. Great care, however, is always necessary to see that the rock is uniformly distributed, and that the mattress is thoroughly down in every part.

Our mattresses have averaged from one-half to three-fourths of a cord of brush to the 100 square feet, which is sunk with from three-fourths to one and one-fourth cubic yards of rock, more being necessary with the second method of sinking than with the first.

2d. Revetment for the protection of high-water bank, which should previously be graded to the required slope, is composed of a frame of stout poles with 12 to 15 foot squares (Fig. 4) well wired at the intersections; over this a heavy layer of brush is placed, then a second frame on top, the whole being sewed and wired through and through. This is to form a base for a covering of rock placed almost in juxtaposition, though frequently we have been obliged to content ourselves with just sufficient rock to keep brush in place. The great enemy of a revetment is the flow of subsoil water from the bank; the drainage of low lands in the rear has greatly lessened this evil.

3d. Foot mattresses placed at the foot of pile dikes have been made from 50 to 100 feet wide, and in construction do not differ from those made for protection of the bank. They are easily sunk even in rapid currents, by starting at the head and keeping the crease of the mattress in the general direction of the current.

4th and 5th. Tipped and grillage mattresses have already been thoroughly discussed under the head of dikes. To sink the former in heavy currents, especially when the direction of the dike is across the flow of the most rapid water, they have been made in short sections thoroughly fastened with lines, and the inner edge sunk until the supporting wires are in tension when the stiffness of the mattress allows the outer edge to go down without much trouble.

QUARTERING AND SUBSISTING OF MEN.

With the large force of laborers employed, it became necessary to attend to the comfort, health, and safety of the men, and it is believed that the form of quarter-boat already mentioned meets all that is required without unnecessary expense.

These boats are used exclusively by the mattress parties, each quartering from 100 to 125 men in all, who are provided with, and held responsible for, mattresses and bedding. Bread, fresh meat, and ice are delivered by the tow-boats each day, and general stores every 15 days on requisitions of the boarding masters in charge, who also furnish each month an account of the amount used, number of meals furnished, &c., from which the cost of a ration is deduced. This has averaged about 29 cents for the raw and 40½ cents for the cooked ration for one man each day.

Each pile-driver has quarters for its foremen and crew, while every fifth driver has extra accommodations for kitchen, dining-room, and fleet foremen, and can furnish meals for fifty men.

A bakery was built at Plum Point to furnish 400 to 500 loaves of fresh bread a day, but will soon be transferred to floating quarters as more convenient during the higher stage of the river.

Very respectfully, your obedient servant,

ARTHUR J. FRITH,
United States Assistant Engineer in charge.

Capt. JOHN G. D. KNIGHT,
Corps of Engineers.

I 2.

REPORT OF GEORGE W. GENDER, ASSISTANT ENGINEER, UPON OPERATIONS AT GOLD DUST, TENNESSEE.

GOLD DUST, TENN., *October* 31, 1883.

CAPTAIN: I have the honor to submit to you the following report of operations at Gold Dust, Tenn., from December 1, 1882, to October 31, 1883:

The present condition of the work at this point is represented on the sketch forwarded with this report, Plate III; also the total amount of construction completed, the notes of which are placed upon the sketch. Stations were established every 100 feet to refer the work to.

Operations at this locality were in progress on the 1st of December, 1882, and continued up to this writing with such interruptions only as were made necessary by unfavorable stages of water. This year has been remarkable for its protracted period of high water, which divided the year into two distinct working seasons.

The work done at this point previous to December 1, 1882, consisted of a main dike 5,200 feet long, from Station 47 to Station 99.

On December 1, 1882, a force of men, with their quarters and a complete outfit for constructing footmat, was transferred from Ashport to Gold Dust, and the construction of a mat 100 feet wide, placed directly in front of the main dike, was begun.

Two small mattress boats, each 100 feet long, were used; one, commencing at the up-stream end of the main dike at Station 97+57, constructing a continuous mat 1,713 feet long, and the other, beginning near the middle at Station 74, constructing a continuous mat 2,951 feet long, which extended to the lower end of the dike.

On the 10th of December a fleet of 10 pile-drivers arrived and commenced driving on Cross Dikes Nos. 1 and 2. During the first ten days of January this fleet was increased to 17 pile-drivers. These dikes were constructed after the improved form introduced by order of Mr. A. J. Frith, assistant engineer in charge, and consisted of two rows of piles 14 feet apart, with piles in each row spaced 7½ feet between centers. Longitudinal riders were placed on the entire length of both rows, secured to the piling by drift-bolts and wire. The two rows were joined by horizontal braces placed in the direction of the current as near as might be, and resting on the riders of both rows. They were drift-bolted and wired to pile and rider. This construction was strengthened by wire cables, consisting of six strands of No. 8 wire, which were fastened to the piles in the front row 16 feet (required penetration) above the lower end of the pile, and around pile, brace, and rider of the rear row.

After Cross Dikes Nos. 1 and 2 had been completed, with the exception of a passage way for barges and material, the river began rising. In order that piles might be driven over that portion of Elmot Bar, which was exposed at low stages, pile-drivers were moved to the bar end of Cross Dikes Nos. 3, 4, and 5. The water continued to rise and soon submerged the dikes when operations were necessarily suspended, February 21, with the river at a 30-foot stage. The force was reduced and pile-drivers transferred to Plumb Point to make necessary repairs and alterations for better continuance of work.

During the time of operations 4,899 linear feet of dike were driven. There were also constructed 4,664 linear feet of footmat 100 feet wide at the main dike, 738 linear feet 50 feet wide at Cross Dike No. 1, and 1,270 linear feet of footmat 50 feet wide at Cross Dike No. 2. The largest amount of footmat constructed in any one day on one mattress boat was 251 linear feet. Wattling 10 feet wide was placed on the main dike for its entire length.

When the water began rising there were 2,420 linear feet of footmat on the surface of the water and no stone could be procured.

At the lower end of the main dike 412 linear feet were still afloat. Quantities of drift crowded beneath the mat, increasing the current under the mat to such an extent that it caused a deep scour at the piles. As soon as this scour was noticed sacks were sent for, but before these were filled, loaded, and towed in place, this portion of the dike was scoured out and the accumulated raft, consisting of dike mat, and drift proceeding down-stream struck Cross Dike No. 3, which was temporarily able to resist the great pressure, but being unprotected by a footmat, after several days a portion of it scoured out.

This mass of drift, driven by the swift current, struck Cross Dike No. 4 with irresistible force, demolishing a portion of that dyke.

At Cross Dike No. 1, 738 linear feet of footmat, and at Cross Dike No. 2, 1,270 linear feet of footmat 50 feet wide were still afloat, and the sand bags were used on these with success. By this time the dikes were entirely submerged, and the mats were anchored by wires fastened to the piles. Sinking was done from skiffs, as the drift above and the dike below the mat prevented the use of barges. Sinking was very difficult, as the current was at right angles to the line of the dike, and therefore had a tendency to double the up-stream edge under or over. The mat being driven down-stream by the drift and current, the lower edge necessarily landed on the front piling, where it remained after the up-stream edge was sunk.

On account of the accumulation of drift in front of the main dike, work on footmat had to be suspended before the upper section was completed, leaving the main dike unprotected from Station 74 to Station 79+60. The river at this time was at a 20-foot stage, rising at the rate of one foot per day, and carrying heavy masses of drift. In its efforts to follow the more direct channel through Elmot Chute the current broke through the main dike where it was unprotected by footmat at Station 75, and this mass of drift took out a portion of Cross Dike No. 2, represented on sketch by the letters *a b*.

The water rushing through this gap with a velocity of not less than 5 miles per hour, and carrying heavy masses of drift which struck the edges of the breach, breaking pile after pile, soon increased the length of the breach, which was again increased during the second rise. The gap in Cross Dyke No. 2 was not increased, the dyke being 10 feet lower than the main dike.

No attempt was made to repair these gaps, as the dikes were submerged.

In making an examination of the works at a low stage of water, it was found that the main dike had been damaged to a greater or less extent from Station 77+50 to Station 65+50, and from Station 59+60 to Station 47. That portion of the main dike above the upper breach was found uninjured, with the exception of a few riders and braces, which were crushed by the weight of drift resting on them after the water had fallen.

Although the water was 7 feet above the tops of the piles the drift did not pass over the dike, and at some places it is 60 feet wide and solid to the bottom.

Where the dike was not protected by footmat small channels formed, having sufficient velocity to erode the bed.

Cross Dike No. 1 remained intact, and has a deposit in its rear as high as the dike in some places.

The foot-mat in front of that portion of the main dike which was carried away remained uninjured, and is covered for its entire length with large gravel, although there was a scour of several feet on both sides of it. The new dike has since been driven through this foot-mat.

The greater portion of the damage done to these dikes was due to the sudden rise of the river before the work could be completed; nevertheless large deposits were made within the area that would be inclosed by the work when finished.

At the main dike the deposits formed immediately behind the dike, while at the cross dikes the material was deposited some distance below the dikes, and nearly to the top of the piles.

At Cross Dike No. 2, where the lower edge of the foot-mat rested upon the dike, the deposit formed immediately under the mat and does not extend for any distance below the dike. This deposit consists of large gravel. The success of this accidental construction suggested the building of similar structures in hopes of obtaining like results.

On April 16, with the river at a 28.35-foot stage, work was resumed and was continued with a force which was increased and decreased as the stage of the water became favorable or unfavorable for work.

The eastern end of Elmot Bar being submerged, advantage was taken of the high stage of water to extend the western end of the main dike and northern end of Cross Dikes Nos. 3 and 4 to their junction with the main dike. The construction of these lines was pushed forward vigorously, employing four pile-drivers on each of the mentioned dikes. The four drivers (Nos. 19, 20, 21, and 28) stationed at the main dike were new and were a decided improvement on the old ones. The height of the leads being increased to 45 feet, allowed the greater portion of the piles to come under the hammer before lowering them into the water; while with the old leads, which had a height of 31 feet, at a low stage of the river piles had to penetrate for several feet before they could be brought under the hammer. The new drivers were also equipped with large Worthington compound duplex steam pumps, having two 10-inch and two 16-inch cylinders. The old drivers were equipped with single-acting piston pumps having an 8-inch cylinder.

At this point driving has been exceedingly difficult on account of layers of very coarse gravel and blue clay. Pieces of gravel weighing half a pound have frequently been found.

At some places piles had to be pointed and driven, as the 1¼-inch jet of the old drivers was unable to displace the coarse gravel. The new drivers using a two-inch jet were able to work through these hard strata without pointing the piles, but not without a liberal use of the hammer. As soon as the piles had passed through the hard layers they would sink to the required depth of 16 feet with little difficulty.

About the 1st of May the construction of a grillage mat between the two rows of piles, and extending about 10 feet in front of the dike, was begun at Cross Dike No. 4. Sections of mat 60 by 35 feet were constructed, and consisted of a thick, coarse brush lying in the direction of the current, firmly lashed to a grillage of poles which was suspended about 1 foot above the surface of the water by wires fastened to the braces of the dike. As soon as a section was completed the wires were taken off and it was sunk to the bottom with stones. These sections overlap about 7 feet.

A foot mat 100 feet wide placed directly in front of the main dike was commenced at Station 21+25; but work had to be suspended after completing 164 linear feet, on account of the drift accumulating in front of the dike, making it almost impossible to move the mattress boat.

Work on these lines was carried on until about the 1st of June, when they were compelled to desist on account of the high stage of the water.

While the work of extending these lines was thus delayed, eight pile-drivers were moved to Cross Dike No. 5 and its construction pushed forward. Four pile-drivers were transferred to Bullerton.

From April 16 to June 1 there were driven 5,200 linear feet on the main dike, 1,900 linear feet on Cross Dike No. 3, and 2,800 linear feet on Cross Dike No. 4. There were also placed 2,200 linear feet of grillage 40 feet wide on the main dike, 1,600 linear feet 35 feet wide on Cross Dike No. 4, and 850 linear feet 35 feet wide on Cross Dike No. 3. Wattling 6 feet high was placed on the main dike for 800 linear feet, on Cross Dike No. 3 for 800 linear feet, and on Cross Dike No. 4 for 1,020 linear feet.

During the unexpected rise considerable damage was done to the main dike above Station 36 and to the south end of Cross Dike No. 3, which was due to the unfinished condition of these lines.

After the water had fallen it was found that the portion of Cross Dike No. 3 lying south of Station 8+50, the end of the grillage, was damaged to a greater or less extent by the piles scouring out and by the inability to secure the diagonal cables before the dike was submerged, the intention being to secure them after the grillage was constructed and sunk. A breach of about 100 feet was discovered above Station 36 on the main dike and one from Station 43+50 to Station 51.

The pieces of dike which had been scoured out floated down to Cross Dikes Nos. 4 and 5, and the piles are there being utilized to support the tip-mat. All of these piles were scoured out, as none were found broken. During the rise large deposits formed immediately in the rear of the main dike.

A bar whose crest became dry when the river fell to a 26-foot stage extended nearly the whole length of the main dike below the lower breach. The largest deposits were made at the junction of Cross Dikes Nos. 3 and 4 and the main dike.

The point of Elmot Bar, lying to the northward of the main dike, within the space allotted to the channel, was washed away during this rise, and deposited in the rear of the main dike. This point previously caused a large percentage of water to pass through Elmot Chute, thereby increasing the pressure on the dikes during high stages of the river.

At the outer edge of the foot-mat on the main dike a scour has been noticed for the entire length of the concave portion.

It was noticed that where drift had accumulated in front of the cross dikes a scour has taken place equal in volume to that of the drift, and that after the water had left the bar the drift would exactly fill the space scoured out.

The water having fallen, operations were first resumed upon the gap in the main dike, at Station 36, and upon Cross Dike No. 3, at Station 8+50. The main dike was strengthened wherever small channels were discovered passing through it, by driving clusters of two piles in the front row, and also a third row. The piles in the front and second rows were supplied with cables which were fastened around pile, rider, and brace of the third row, to conform to the "Standard Dike," at this time introduced by Mr. A. J. Frith.

The pile-drivers were able to complete all dikes before the water left the bar, but the mattress work was delayed by inability to obtain material owing to the flooding of the willow camps. Grillage and wattling is now being completed on dry land, the necessary brush being supplied from the head of Elmot Bar.

To save the transportation of rock across the dry bar, tarred sacks filled with gravel and sand are being substituted.

That portion of the main dike which was driven before the 1st of December, 1882, has been strengthened by driving two rows of piles in front of it and using the old dike as third row. Considerable difficulty was experienced driving through the old foot-mat, which was covered with coarse gravel.

This portion of the dike is being protected by a tip-mat from 38 to 60 feet wide, constructed in sections of 150 feet. The mattress boat is placed parallel to the dike, that portion of the ways extending over the gunwale of the barge having been taken off. Poles are evenly distributed over the ways and their lower ends firmly secured to the riders of the dike. The brush is wattled upon the poles by passing a rod of it alternately above and below them. The mat is strengthened by placing poles above and beneath the wattling pole, firmly lashing them with No. 12 wire. A section of 150 feet having been completed, the mattress boat is sparred from under the mat, and the up-stream edge sunk to the bottom.

In the deep channel near the Tennessee shore a tip-mat 75 feet wide is being constructed in front of Cross Dikes Nos. 3, 4, and 5. The mattress boat is placed at right angles to the dike, the ways nearest the dike having been raised to the level of the riders to maintain the mat at that height after it is launched from the mattress boat. While launching the mat, piles are floated under it. The up-stream ends of these are wired to the poles of the mat, and the down-stream ends raised to the level of the riders, where they are drift-bolted and wired to the piles of the dike. The up-stream end of the mat is then sunk to the bottom. In swift currents this mat is constructed in sections 130 feet long, about the length of a rock barge, as the mat has to sink for its entire length simultaneously to prevent the up-stream edge from doubling over or under.

Where the main dike and cross dikes strike the Tennessee shore, the bank has been protected by a mattress 350 feet long, and varying in width from 50 to 100 feet. The dikes were completed to this mattress, leaving a mattressed opening for navigation nearly 100 feet wide. The bank at these places has been graded, and bank protection is being placed.

Grading was done with pile-driver No. 19, which is equipped with a Worthington compound duplex pump, having two 10-inch and two 16-inch cylinders. The discharge, about 420 gallons per minute, passes first through a 4-inch pipe, then through a 2½-inch hose, and is delivered through a 1¼-inch nozzle.

Table giving length of completed work as represented on sketch.

Dikes.	Number of linear feet of dike.	Number of linear feet of grillage or old foot-mat.	Number of linear feet of wattling.	Number of linear feet of tip-mat.	Number of linear feet of grading.	Number of linear feet of bank protection.	Number of linear feet of mattress.
Main Dike	9,457	8,311	1,600	1,325	....	410	350
Cross Dike No. 1	700	200	....	....	....	....	....
Cross Dike No. 1*a*	630	225	....	....	....	....	....
Cross Dike No. 1*b*	200	....	....	....	....	....	....
Cross Dike No. 2	700	350	....	....	....	....	....
Cross Dike No. 3	2,910	2,810	850	....	320	....	308
Cross Dike No. 4	4,400	2,630	1,020	300	350	....	340
Cross Dike No. 5	3,400	3,100	450	1,505	....	....	....
Total	22,397	17,626	3,920	3,130	670	410	998

Very respectfully, your obedient servant,

GEO. W. GEUDER,
United States Assistant Engineer.

Capt. JOHN G. D. KNIGHT,
Corps of Engineers, U. S. A., Cairo, Ill.

I 3.

REPORT OF CHARLES D. MARK, ASSISTANT ENGINEER, UPON OPERATIONS AT OSCEOLA UPPER AND LOWER BARS.

OSCEOLA BAR, *November* 1, 1883.

CAPTAIN: I have the honor to submit the following report on the progress of the work at Osceola Upper and Lower Bars:

During the period from December 1, 1882, to November 1, 1883, two old dikes, Osceola Upper and Middle, were finished, and three new ones, Secondaries Nos. 1, 2, and 3, built. The mattressing and revetting of both Osceola Upper and Lower Bars has also been started.

In the following I shall take up the separate structures and give as far as possible a short history of each.

OSCEOLA UPPER DIKE.

Though the greater portion of this dike was built previous to December 1, 1882, the finishing and partial destruction of same fall within the scope of this report. The methods of construction typified in it may therefore be briefly reviewed.

The dike running in a general southwesterly direction from a point below Lynch's Landing, Ark., to the northern end of the Upper Osceola Bar, was built for a distance of 3,300 feet, of a single line of piles, braced by inclined struts. At the head of the bar a gap had been left, which it was attempted to close in April, 1883, by means of an extension, consisting of a double line of braced piles, 14 feet apart; 168 linear feet of this kind of dike had been driven, when the swift current made it apparent that the work would be in vain. It was therefore abandoned, and Secondary No. 1, of which more later on, put in. Osceola Upper Dike, protected its whole length by a foot-mat 100 feet wide, and by wattling, stood the high water last spring remarkably well, when the inherent weakness of the structure is considered. From all data which I have been able to obtain it seems that the breaks, which now for a length of 1,600 feet appear in the dike, are not due to any scouring action in front of the latter, but to a simple breaking off by drift, and working out of the poorly-braced single piles. The portions of the dike executed in shallow water have proved strong enough, while those in deep water have given way. The foot-mat, as I had occasion to convince myself during the present low water, is still in place; a fact which strengthens my belief that no scouring has taken place in front of the dike.

The general effect of the latter has been favorable, though it stood in its entirety for but a short time. A good fill has taken place, higher behind those portions of the dike still standing than at other points. Though part of this fill is also to be traced to the effect of Secondary No. 1, as will be shown further on, it may be said that the result obtained by the building of Osceola Upper Dike is a fair one. The cause of its failure is most likely to be traced to weakness in construction, a fault which could hardly be avoided at the time the dike was designed, for lack of previous experience.

OSCEOLA SECONDARY NO. 1.

When it was found impossible to connect the lower end of Osceola Upper Dike with the point of the bar, a dike further down the chute was projected and carried out. As first planned a double line of braced piles with a width of base equal to depth of water was the type adopted. During the construction of the dike drift began to collect, and a scouring at the foot of the unprotected piles immediately set in. May 10 a break near the bar-end of the dike occurred. In order to enable the closing of this opening the direction of the dike had to be changed at that point, the water proving too deep for successful pile-driving. Luckily the material scoured out was found deposited a little way below the break, having formed a bar there, and the dike could be finished in shallow water, with but little additional lengthening, due to change of direction. It was also deemed advisable to alter the original project by adding a third row of piles, connected by horizontal braces with the first and second rows. Thus strengthened, the dike was completed June 10 in a length of 1,355 feet. The collecting of drift in front of it prevented the sinking of a foot-mat, and as some of the drift also projected back of the first row of piling, only the space between the second and third row could be matted. A grillage foot-mat was put down and carried up to the top of the bank at both ends to prevent any scouring between the shore and the dike. Later events proved the wisdom of this step, for during the high water there was quite a tendency to cut a channel behind the ends of the dike. As it had been impossible, for reasons stated above, to mattress the dike as intended, a constant watch was kept on it during the high water of June–July. By frequent soundings all changes in depth were carefully noted. If there seemed any danger of a scour taking place the threatened portion was protected by fascines. Of the latter two kinds were used. In one case a piece of wire-united willow matting about 8 feet square was made. The rocks were wrapped up in it, and the center and ends of this bundle firmly wired. In the other case bailed rock was tied to willow bundles 6 to 8 feet long, and 1 to 1½ feet in diameter. It was found by inspection, after the high water went down, tha the first kind of fascines mentioned had done the better service of the two. They generally sunk directly in place, while the bailed rock of the second kind, catching on the wire dike cables, prevented the fascine from going to the bottom.

Osceola Secondary No. 1, which stood the high water well, is especially remarkable for the large amount of drift gathered in front of it. For a time the whole head of the chute, from the dike up, was filled completely. Winds blew some of the drift out before it had become firmly packed; but even to date about twenty acres of it remain, closely wedged. Of course this mass has not been without its marked effect. When the drift first began collecting an increased tendency to scour in front of the dike was noticed. The depth of this scour, as might be supposed, was equal to the thickness of drift at the point under consideration. Where it has been possible the so-caused opening has been closed by sinking the drift, a barge of rock being expended to good effect for this purpose in front of Secondary No. 1. Should sinking the drift in similar cases prove impossible, the scouring out of a dike is to be feared, unless it has been well protected by foot-mats.

To the evil effect of the drift, cited above, a good one can be opposed. When the construction of the dike was first begun quite a strong current set through the chute. The collecting drift checked it so completely that when the present amount had come in the current was almost dead. A marked fill both in front and behind the dike has taken place, so that if the holding of the latter should prove successful the direction for future work would seem to be indicated.

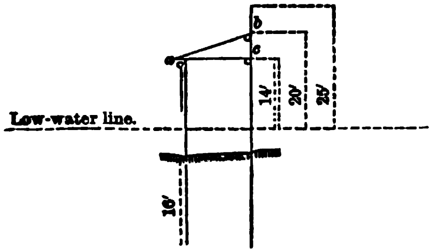
OSCEOLA SECONDARY NO. 2.

The construction of these dikes was pushed at the same time that No. 1 was building. The first section extends from the Arkansas shore to the northern point of the towhead; the second section, from the lower end of this same towhead to the foot of Osceola Upper Bar. The type adapted is the double-line, rectangular, 14-foot base dike, except for the southeastern end of Section 1 and the northeastern end of Section 2. These portions of the dike running up on high ground, it was deemed sufficient to build them of but a single line of piles. In the second section an opening 200 feet in length had to be left to enable the boats to reach the parties at work at No. 1. When the water began falling it fell so rapidly that the pile-drivers had to be moved out before the gap could be closed. With the exception of this piece, then, the 2,025 linear feet of dike are protected by a grillage foot-mat and by wattling.

Begun April 10 and finished May 20, these dikes have passed safely through one high water; but built under the shelter of No. 1, little strain has come on them from drift or other causes. A slight fill has taken place behind both of the dikes.

OSCEOLA MIDDLE DIKE.

Osceola Middle Dike, connecting the foot of Osceola Upper with the head of Osceola Lower Bar was begun November 1, 1882. During December 1,065 linear feet were added to the part previously completed, giving the whole structure a length of 3,309 feet. The form of the dikė adopted was the one as shown here. Top of outside pile driven to a stage of 25 feet. Top of inside pile driven to a stage of 14 feet. Front fore-and-aft rider fastened 5 feet below top of outside pile, rear rider at top of inside pile. Inclined brace *a b*, horizontal *a c;* width of base, 14 feet. A 100-foot mattress was built the whole length of the dike and the latter also wattled. As the water rose covering the lower front fore-and-aft rider it became impossible to push the wattling to the bottom. It would have been better had it therefore been left out entirely, for



the water coming through the chute was pressed through the narrowed opening between the bottom and the lower riders, contributing its share to the strong scour already taking place in front of the dike. The 100-foot mat did not prove sufficient protection in this case, for in February the first break near the center of the dike, and undoubtedly caused by scouring, occurred. Toward the latter part of March pieces of the end sections followed, carried away by drift. An attempt made in May to patch the dike and to strengthen it by two little spur dikes proved unsuccessful. The cause of the failure of this structure, of which to date only 1,059 linear feet in a damaged condition are standing, may probably be looked for in its incomplete protection against scour.

OSCEOLA SECONDARY NO. 3.

Osceola Secondary No. 3, established near the head of Osceola Chute, and running east and west, was begun May 10. Work on it was pushed as fast as possible, but ere it had been finished, high water, with drift and its attendant scour, caused a break near the bar or eastern end of the dike. As at Secondary No. 1, it was also found necessary here to change the direction of the washed-out section, in order to avoid the deep water resulting from the scour. A third row of piling was also put in, as an additional means of strengthening the dike, thus giving it an average width of about 60 feet. As the water continued rising and the drift kept coming in, a renewal of the scour was observed. With the intention of checking it a 75-foot mat in front of the dike was started. When 209 feet of the same had been built, progress was stopped for a time by the drift, which so held the mat barge, that it was found impossible to make a shift. In the hope that a way for the barge might be cleared by sinking the drift, sections of sub-mat were built on the latter and sunk. Two thousand seven hundred feet of this kind of mat went down successfully, and we were enabled to add another 30 feet to the length of the foot-mat, but this was all. For when, June 6, the attempt was made to sink a second section of drift of about 4,232 square feet of surface, the dike, already weakened by scouring, could not stand the pressure of the sinking mass and gave way. Through the break so formed, 140 feet in length, a large amount of accumulated drift passed off, considerably relieving the pressure on the remaining portion of the dike. Steps were immediately taken to prevent any further scouring in the break. A piece of mat was built above the same, floated down, and about two-thirds of it, or 6,800 square feet, sunk in place. As the current was very swift and the average depth of water in the opening 48 feet, one-third of the mat was carried away before we could get it down.

In the mean time the 239 feet of foot-mat had been sunk and a large amount of grillage foot-mat put in. On account of the high water, no attempt was made for some time to close the gap. Repeated soundings showed that no additional scouring was taking place. July 17 a tipped mat, 50 feet wide, was started in front of the dike, where the other footmat previously sunk left off. Only 120 linear feet of this new mat had been completed when a second rise, July 21, brought down a batch of drift, which lodged under the mat, packed itself to the bottom, and thus prevented the sinking of this piece. It lies on top of the drift to date, as shown in the sketch. As soon as the water began to fall, the loose ends of the dike were cut away. A 200-foot opening was so formed in which the pile-drivers were set to work. They barely succeeded in closing it with a single line of cluster piles, when it became necessary to withdraw the fleet, the water shoaling so rapidly. To strengthen this comparatively weak portion of the dike, and at the same time to withdraw it from the future attacks of drift, the piles forming the single closing line were braced by inclined struts and cut off level with the 15-foot stage.

All the remaining portions of the dike had in the meanwhile been protected by a heavy grillage foot-mat. A section of same 200 by 63 feet was also placed behind the opening just closed, but remains unsunk to date for lack of stone. August 7 a tipped mat, 75 feet wide, beginning at the western end of the mat lodged on drift, was started on the up-stream side of the dike. This new mat skirting the outside edge of the drift, and with its (the mat's) down-stream edge held on a level with the same, was carried a distance of 452 linear feet. Shoal water here put a stop to the work, and the amount finished was sunk successfully. From the foregoing it will be seen that Osceola Secondary No. 3 is well protected now. A grillage foot-mat extends its whole length, and is carried high up on both banks. With the exception of the small piece mentioned, all of it is in place, and has done good service during the last high water. The effect of the tipped mat can only be determined after the next rise. The center row of piling is now being wattled, 5,922 square feet having been put in to date. From the plotted list of soundings sent in by me, the fill which has gradually taken place in Osceola Chute can be traced. The evil effects of the break have been obliterated, the scoured hole causing the former having filled up well. I think I am justified in classifying Secondary No. 3 with Secondary No. 1, under the head of successful dikes.

OSCEOLA UPPER BAR.

The head of this bar was well protected by a foot-mat 50 feet in width, and by a 30-foot revetment, closely connected with the former. About 800 linear feet of this hand-graded work were executed, all of which is in good condition to date. That the same cannot be said for some of the other work on the bar is easily explained. A 100-foot mattress was put in the whole length of Osceola Upper Bar and sunk. This was at low water. Though the grading and revetting were started immediately in wake of the mattress, it was impossible to finish them before high water set in. Of 4,050 linear feet of grading put in, 2,100 were rendered entirely worthless, because the water covered the banks before they could be revetted. The 1,400 feet that were covered with brush and partially rocked also suffered heavily, for the reason that no connection between the high and low-water protection could be secured. The banks washing away between the two has left a gap, as shown in sketch, which it will be necessary to fill with a second mat.

OSCEOLA LOWER BAR.

During the high water in June and July, while it was found impossible to work at Secondary No. 3, a 100-foot mattress was started on the inside of the lower bar. Heavy drift running necessitated the building of a drift-boom, in shape of a spur dike from the head of the bar down the chute for a distance of about 100 feet. Under its protection 1,020 linear feet of mattress were built and sunk in place. A small section, 100 by 120 feet, near the head of the bar, was put in when the water fell, and remains unweighted to date for lack of stone. The bank protection on the inside begun June 1 and abandoned June 8, on account of high water, was continued August 13. By the 31st of the same month a total of 72,422 square feet had been made, of which 49,931 square feet remain unrocked to date. Of the 4,040 linear feet of grading put in last January on the outside of this, the lower bar, no traces remain, as the graded bank was entirely unprotected when high water came up. This was to be expected. Eight hundred feet of a 100-foot mattress, which was also started at that time, were caught afloat by the same rise. Drift collected under the mat, and would have rendered all attempts to sink it futile, even if rock had been on hand for that purpose. As was constantly expected, the increased strain on the head-lines, due to the accumulating drift, caused them to part. Even one of the capstans of the mat barge was torn out of its fastenings, when the lines snapped, and mat and drift swung down the river. Of the new one, 150 feet in width, which was started September 1, 3,583 linear feet have been completed to date, but only 920 feet of this amount have been sunk; work on the same has been stopped for the present, it not being deemed advisable in view of former experiences to carry the mattressing too far ahead of the grading and revetting. Another precaution has also been taken. Though the contour of the bar has been closely followed by the mat in most places, it has been impossible to adapt the latter to any sudden changes in the outline of the bank. The small openings thus formed between mat and shore have been covered with separate pieces of grillage mat, firmly wired to the mattress proper. Four thousand four hundred and sixty square feet of this kind of matting have been called for to date, and more will be put in as the necessity for so doing arises. By this means a thorough connection between the high and low-water protection can be obtained, *i. e.*, if the former be put in at the present stage of water.

ADAPTATION OF PLANT FOR PURPOSES INTENDED.

In accordance with your request, I submit, in addition, the following opinion, as to the adaptation for purposes intended of those articles of plant which I have had occasion to use.

The 100 foot mat barges, with ways 30 feet long, and a slope of the latter of about one-ninth, do not fill all the requirements that must be met. Great difficulty in launching the consecutive shifts of a mattress was constantly experienced. This is partly due to the slight slope of the ways and partly to the fact that so little space remains between the lower end of the ways and the deck of the mat barge that the lower (front) end of the mattress rests on the deck of the barge. In addition the outside butts of the willows do not pay freely over the end kevels, and the want of a capstan was severely felt. The 175 and 213 foot mat barges, built with projecting and more sloping ways, answer their purpose admirably. The latter barge, on which the mattress on the outside of Osceola Bar is now building, can, however, only be used to advantage in slackwater. In a strong current the handling of it becomes almost an impossibility, as I found when this barge was swung across the break in Osceola Secondary No. 3.

The service barges belonging to the reach answer all requirements.

The new general service barges, 120 by 30, used especially for the transportation of rock, are somewhat unwieldy. Even if supplied with capstans, which they are not, it will always be a matter of some difficulty to handle them with a load of 300 cubic yards of stone.

A sketch, with a table thereon, giving full dimensions of all work done in the period from December 1, 1882, to November 1, 1883, accompanies this report (Plate IV).

I am, very respectfully, your obedient servant,

CHAS. D. MARX,
United States Assistant Engineer

Capt. JOHN G. D. KNIGHT,
Corps of Engineers, U. S. A.

I 4.

REPORT OF AUG. J. NOLTY, ASSISTANT ENGINEER, UPON OPERATIONS AT BULLERTON TOW-HEAD.

BULLERTON TOW-HEAD, *November* 15, 1883.

SIR: I have the honor to submit herewith my report of operations at Bullerton Tow-head, covering the period from December 1, 1882, to November 1, 1883.

In compliance with verbal orders received from First Lieut. Thomas W. Symons, Corps of Engineers, I assumed charge of this work on April 14, 1883, relieving Mr. Charles A. Ankele, who had tendered his resignation. Upon my arrival here all active operations had, by reason of high water, ceased, and the small force left was employed in the care and preservation of public property.

The river having fallen sufficiently by May 12, the force of laborers was increased, and the construction of foot-mats along both sections of Osceola–Bullerton Dike was begun. During the latter part of May work along the north bank of Bullerton Tow-head was resumed by commencing the construction of two foot-mats and a high-water bank protection. A small force were also employed clearing the bank for a distance of 50 feet back of drift and standing timber. These operations were continued until the middle of June, when the river again rose above the bank and put a stop to all further work.

On June 23 the greater part of the force were moved up to the stone depot at Gold Dust, Tenn., where they were employed in loading stone on barges, a party of seven men, in charge of one foreman, being left at Bullerton to take charge of the plant remaining there.

By July 5 the water had fallen sufficiently to admit of resumption of work at this place. The party were therefore moved back, and the construction of inclined foot-mats between piling of Osceola–Bullerton Dike and Bullerton Dike No. 1 was begun, the river being still too high for work along the bank. The latter work was resumed about the middle of the month, and has been continued to date with only occasional and short interruptions, caused by unfavorable weather and delay in getting brush and stone.

Owing to the long season of high water the first half of the current year has been very unfavorable for the proper prosecution of the work, and by far the largest part has been accomplished since July.

Some of the work completed during the flood season was found on the subsidence of the water to be badly damaged, so much so that it was considered advisable to reconstruct parts of it. Notably was this the case with two sections of foot-mat, which, before stone for sinking it could be had, were carried by the rising water over the bank of the tow-head.

This part of the bank had not yet been graded, and as the river fell the bank began to cave underneath the mat. As this caving was very irregular, the water, as it fell, left the mat, at such places where no caving had taken place, high upon the bank; while at other places, where the bank had caved, the mat was out of sight. The above-water portions of the mattress were therefore cut away and new foot-mats constructed. Some high-water bank protection was also damaged and some lost altogether. This damage and loss was caused by want of stone to properly load it.

Some of this revetment as well as a part of the foot-mat was loaded with sand-sacks, but this was found to be a very unsatisfactory expedient, principally by reason of the poor quality of the sacks and their loose texture. The sacks would soon rot and the sand wash out.

Eighteen hundred feet of mattress, 100 feet wide, and 1,250 feet of bank revetment, from 25 to 60 feet wide, was damaged as just described and had to be renewed.

Considerable difficulty has been encountered during the prosecution of the work from the very strong current running here. Between Ranges 50½ and 52, float-observations taken in August gave a velocity of current of 5.35 miles per hour, depth of water ranging from 25 to 50 feet. The upper half of the tow-head is much more exposed to the erosive action of the current, as here it is deflected against the bank, striking it at an oblique angle. This deflection, as well as increased velocity, is caused mainly by the sand-bar opposite, which approaches quite close to the tow-head, thus narrowing the water-way.

Below Range 52 the bar recedes again, making a wider water-way, decreasing the velocity of the current somewhat, and making its course more parallel with the bank.

The erosion of the bank has entirely ceased since the foot-mats were sunk. At several places, however, it was found that portions of the bank would settle down and gradually slide into the water. Examination revealed the fact that this was caused by seepage from a marsh in the interior of the tow-head. It was decided to drain this toward the south bank, and 2,425 linear feet (equal to 1,479 cubic yards excavation) of ditching was done. The depth of water in the marsh varied from 1 to 5 feet, and its level was 11 feet above the surface of the river. Since this marsh has been drained no further trouble has been experienced.

The only work done on the south bank or Arkansas side of the tow-head has been to temporarily check the erosion of the bank near Range 52.

Here the bank for a distance of nearly 1,000 feet began to cave early in the summer, and to check this the trees standing near the edge of the bank were felled so that they would fall into the water at right angles to the bank, their butts resting upon it. These trees were then loaded with bailed stone. This work seems to have stopped the caving. It was not considered necessary to do any work of a permanent character here, as when the dikes are completed the chute will fill up.

All the mattresses made along the banks of this tow-head, with the exception of 350 feet, are of the wire-net pattern. This mattress constructed on specially designed machine barges has for its foundation a wire netting made of galvanized iron wire of No. 8 and No. 12 gauge, the heavier wires running longitudinally or up and down stream, the smaller transeversely. The distance between the longitudinal wires, which is the limit of the length of the mesh, is 4 feet, while the distance between the others can be varied. A mesh 4 feet long by 2.5 feet wide has been adopted here. The brush is carried by suitable machinery operated by steam-power from the brush barge over the mattress barge, and deposited upon the netting, where it is received by men standing upon the mattress and supplied with long hooks, who pack it close together, at the same time seeing that it breaks joints properly to give it the requisite transverse stiffness. After brush sufficient for a shift has been thus disposed upon the netting, brush binders are passed over. These are inserted with their butts into and at least 8 feet through the netting, and then bent over the brush just laid and wired to the netting. These binders are of course placed at right angles to the brush, and that part of their length beyond where they are wired will be under the succeeding shift. This makes an excellent mattress, being very flexible in a longitudinal direction, having the necessary transverse stiffness, and is rapidly constructed. One hundred and eighty linear feet have been made in a day of ten hours when the current was moderate, and the party not subject to delays in getting brush. Three hundred and fifty feet of the mattress made here was of the regular pole pattern, where the brush is alternately woven over and under the poles.

When the mattress between Ranges 51 and 52 was begun, it was evident that a mattress of great longitudinal strength to withstand the great strain which would be thrown upon it during the operation of sinking would have to be constructed here; hence the single No. 8 wires were replaced by wire cables made of six of the former wires well twisted together. These cables were placed 7 feet apart. In other respects this mattress is similar to the one just described.

The high-water bank protection whose lower edge laps over the inner edge of the foot-mat, and which extends to the crest of the bank, consists of a loose brush mattress continuous for its entire length.

This mattress is covered with stones, they being placed close together but only one layer thick.

At such places where, owing to slight settling of the foot-mat, the high and low water bank protections do not make a good lap, small sections of mat, 100 feet long and wide enough to cover the gap, were constructed upon an ordinary barge placed close to and parallel with the bank. One end of these mats rests upon the revetment, and when finished the barge is pushed from under the mat, allowing it to fall down, after which it is sunk.

Considering the amount of work done, the depth of water, and the velocity of current, very little loss or damage to the work has been sustained, and it mostly occurred during the operation of sinking the mattress, which has always been the most difficult part of the work. A section of mattress, 300 feet long by 100 feet wide, in course of construction, broke away during the night of August 22, carrying with it the mattress and three other barges. This loss was caused by the caving of the bank. The mass of earth and stumps falling upon the mooring lines parted them, thus setting the mat free. As soon as the accident was reported by the watchman, men were sent out with anchors and lines, who, after cutting the mat away, succeeded in anchoring the barges off Fort Pillow, from whence they were towed up the next day. The piece of mat cut away lodged on a drift pile at Island 34, and as it was feared that it might cause an obstruction to navigation, a small party was sent down to recover what rope there might still be upon it, and to cut it up into small sections, which were allowed to float away. About 500 linear feet of mat was so badly torn up in sinking that new mattress had to be constructed. This is exclusive of the damage resulting from high water, and of which mention has already been made.

As the work at this place will ultimately be subjected to a very severe test, the utmost care has been taken to do it properly, and to impart to it that permanency which such work requires in order to answer the purpose of its construction.

Whenever a new section of mattress was begun it was made to overlap the preceding section by at least 25 feet, thus practically making a continuous mattress. The mattress was made to follow the indentation of the bank as close as possible, and where this, owing to the depth and shortness of the pockets, was not practicable, narrow supplementary mattresses were constructed after the principal one had been sunk, these small ones well overlapping the inner edge of the larger ones.

The sketch accompanying this report shows the condition of the work up to date. By referring to it, it will be seen that the length of bank operated upon is 9,625 feet. Of this 7,500 linear feet have been graded by the hydraulic grader and 1,525 feet with shovels, leaving 600 feet still to be graded. Five hundred feet of foot-mat and 2,700 feet of revetment yet remain to be constructed, while of the revetment made a large amount remains to be loaded with stone. That part of foot-mattress at the head of tow-head bounded on each side by Range 50 was constructed prior to December 1, 1882. All the other work has been done since that date.

Wherever the foot-mattresses have been sunk the erosion of the banks has entirely ceased, even at those places where the current strikes the bank directly, and which prior to the construction of mattresses were caving rapidly. Some of the finished work has been exposed to the various stages of the river from a complete submersion to very low water and has stood the test without sustaining the slightest damage.

The dikes, too, though not yet finished, have done admirable work in deepening and widening the channel along the tow-head. Soundings taken in October, when the river was very low, show nowhere less than 12 feet of water, while at most places the depth is much greater. The least depth is at the upper entrance to the channel. None of our steamers have had the slightest difficulty in delivering supplies here, and they have at all times been able to tow the most heavily-loaded barges through.

At the opening of the work last year, nearly all the towing had to be done through the chute on the Arkansas side, and around the foot of the tow-head up as high as they could go.

Attention is respectfully called to the urgent necessity of completing this work before the high-water season sets in. Should the river rise 4 or 5 feet above the present stage, great damage would be done to the unloaded revetment, and a higher rise would seriously damage that part of the bank at the middle of the tow-head not yet protected, and endanger the finished work below.

Appended is a table showing the amount and kind of work done and giving dimensions of the same. No account of the work along dike is taken, as that will appear in the report of the assistant engineer now in charge of the completion of those dikes.

All mattress of a less width than 100 feet is such as has been laid inside of main mattress for the purpose of covering gaps left by the latter. The piece of 150 feet width was laid where the inclination of the bottom was exceptionally steep.

The total length of mattress and revetment made will be found to be respectively 2,741 and 1,250 feet, in excess of the length of bank operated upon. This excess is caused by the reconstruction of damaged work, by the construction of mats to fill gaps between the main one and the shore line or revetment, and by the amount of overlaps.

Work done at Bullerton Tow-head from December 1, 1882, to November 1, 1883.

Class of work.	Dimensions.	Totals.
Foot-mattress made and sunk..	10,319 by 100 feet, 355 by 150 feet, 298 by 75 feet, 394 by 37 feet.	12,366 feet = 11,220 squares.
Revetment made	8,140 by 70 feet	8,140 feet = 5,698 squares.
Revetment loaded	3,531 by 70 feet, 1,454 by 40 feet......	4,985 feet = 3,053 squares.
Bank graded..............	8,900 by 65 feet	8,900 feet.
Poles cut, cords	233..............	233 cords = 97,860 feet.
Brush cut, cords..............	760..............	760 cords.
Ditching	2,425 feet	2,425 feet = 1,479 cubic yards.

Respectfully submitted.

AUG. J. NOLTY,
United States Assistant Engineer.

Capt. JOHN G. D. KNIGHT,
Corps of Engineers, U. S. A.

I 5.

REPORT OF F. A. YEAGER, ASSISTANT ENGINEER, UPON OPERATIONS AT OSCEOLA-BULLERTON AND PLUM POINT DIKES.

PLUM POINT DIKE, *November* 1, 1883.

CAPTAIN: I have the honor to submit herewith a report of progress of the work on Osceola-Bullerton and Plum Point Dikes from December 1, 1882, to October 31, 1883.

OSCEOLA-BULLERTON MAIN DIKE.

In referring to this dike, that part starting from Osceola Bar will be called North Dike, and the part starting at Bullerton Tow-head, South Dike.

On December 1, 1882, about 1,200 feet of North Dike was standing, and on March 12, 1883, a fleet of eight drivers was put to work, driving until April 13, between which date and the 18th all drivers were moved to Gold Dust. The dike was then completed all but two openings, one of 200 feet, 900 feet from south end of South Dike, and one of 250 feet, about 300 feet farther. From April 18 to June 1, 200 feet of dike between the two openings, and 500 feet, about 400 feet from south end of South Dike, washed out, on account of drift and no foot-mat. June 1 the drivers were again put to work, and on June 22 the mouth of chute was closed, all but a gap of 250 feet, about 1,500 feet from south end of South Dike, and from June 22 to July 10 drivers were idle on account of having no piles long enough for depth of water. Between July 16 and 20, 600 feet between Ranges 49 and 49½, having no foot-mat, scoured out, and on the night of the 21st a large raft of logs lodged on the head of remainder of South Dike, and although this part had been matted, inside and outside, about 200 feet gave way. The washing out of this part may be said to have been caused by drift, large quantities of which had accumulated on dike, extending out farther than the mat, thus promoting scouring action under the mat at its outer edge.

During the night of July 23 the steamer J. S. Woods, with tow of empty barges flanked in on dike where Range 49 crosses, catching pile driver No. 17, and pushing her through and up the front row of piling, about 150 feet. Shortly after this 454 feet near the same place scoured out, caused by collapsing and imperfect sinking of mat. Clusters of three piles were then driven about 10 feet apart, and the tops connected with a heavy wire cable. A mat 100 feet wide and 250 feet long was made on upper side of these clusters, but collapsed before sinking was commenced; 250 by 40 feet remained good and was sunk. The clusters stood erect for three days, when they bent over, and about two weeks later washed out or broke loose. At this time, August 15, it was almost impossible to drive to any advantage, on account of rapidity of current and scarcity of long piles. All dike was now matted, and as the water was too low for boats to run outside of tow-head, a gap of 900 feet was left open for navigation, and all force moved down to finish Bullerton Cross-Dike No. 1. Between September 10 and 20, 375 feet of dike was added to south end of North Dike, and about 50 feet to north end of South Dike, making North Dike 3,995 feet in length, and South Dike 959 feet, with an opening of 900 feet between them. One thousand three hundred and fifty feet of North Dike is completely covered with sand, and all the rest partly covered but 500 feet at south end. The general condition of dike is given on the accompanying sketch.

BULLERTON CROSS-DIKE NO. 1.

This dike is composed of two parts, one on east side and the other on west side of Bullerton Chute.

West Dike runs on a line from 49½ Ark to 52 Bullerton Tow-head, and is 570 feet in length. East Dike starts midway between 50 and 50½ Bullerton Tow-head, and runs toward a point 200 feet below 50 Ark. It is 1,200 feet long and makes a curve at 1,130 feet in the direction of West Dike. Some difficulty was experienced in the building of West Dike, as for a time the piling washed out very fast, but after being matted with inside and outside tip-mat, scouring action ceased, and since that time a fill of 10 feet has taken place, where previous to sinking of mat I reported five piles washed out, and 47 feet of water. The shore at end of dike is protected with 200 by 50 feet of bank protection above and 150 by 50 feet below dike. Also a foot-mat of same length, but 100 feet wide. Each dike is all matted inside and as far as practicable outside.

Both East and West Dikes are in good condition, and a noticeable fill is taking place above and below each. From present appearances the chute is slowly filling up and the channel going on the outside of the tow-head.

PLUM POINT DIKES.

These dikes were started September 20, and as yet little progress has been made owing chiefly to scarcity of material. Up to date work has been done only on Main Dike and Cross-Dikes 1 and 2. The amount of dike completed and incomplete is given on sketch. Five hundred and fifty-six feet of Main Dike has 100 feet foot-mat, and 458 feet has inside or grillage mat between the second and third rows. The grillage mat is a tip-mat, and was sunk to-day. The foot-mat has not yet been sunk. All foot-mat on Main Dike, according to orders, will be sunk flat, and cross-dikes will have grillage tip-mat and 50 feet tip-mat outside. The shore at head of Main Dike is protected by a revetment 290 feet long and 65 feet wide. The small gap between end of Main Dike and shore will be closed in a few days and cross-dikes will be finished to shore as soon as possible.

If the material can be had, Main Dike as far as Cross Dike No. 2 and Cross Dikes 1 and 2 can be protected by the latter part of December.

PLANT.

The small, low, 100-foot mat barge used by me in Bullerton Chute is almost useless for making mat in swift water, as it has but one kevel on each end and no capstan. The new large 157-foot mat boat, with capstan on each end, I am now using is all that could be desired.

The pile drivers have done very well, but the circular lead drivers are at times very awkward to handle, and are the cause of considerable delay. The side lead drivers are much more convenient and in every way preferable to circular leads.

Very respectfully, your obedient servant,

F. A. YEAGER.

J. G. D. KNIGHT,
Captain of Engineers, U. S. A.

I 6.

REPORT OF A. P. HATFIELD, ASSISTANT ENGINEER, UPON HYDRAULIC GRADING OPERATIONS.

ELMOT, ARK., *November* 13, 1883.

SIR: I have the honor to submit the following as my report of the hydraulic grading performed in Plum Point Reach since December 1, 1882.

On that date I was placed in charge of Grader No. 4. This grader has two Davidson pumps, independent action. Plungers 16 inches diameter, driven by two compound engines, the initial or high-pressure cylinders being 18 by 24 inches, the low-pressure cylinders 34 by 24 inches. Steam is supplied by a battery of three boilers, 22 feet long, 44 inches diameter of shell, with five 10-inch flues. Area of grate surface, 56 feet 3 inches. The vacuum pumps are also of the Davidson style, steam cylinders 10 by 16 inches, water cylinders 12 inches diameter. The water supply came from two wells directly below the pumps; these are 3 feet square, the water passing through two strainers of 2,500 ⅜-inch holes. The suction pipe is 14 inches diameter. The discharge is through a boom pipe 60 feet long, having twelve openings fitted with 4-inch valves; to these the hose is attached. The hose outfit consisted of 4-inch hose—six sections 50 feet each; two sections 25 feet; two sections 12 feet 2½ inches. Rubber 6-ply hose, four sections, 50 feet, with nozzles 1¼, 1½, and 2 inches.

December 2, the grader was taken to the head of Bullerton and began work on the west side. Here we graded, up to February 9, 9,432 linear feet, and 98,546 yards. Up to this time the total operating expenses were, for labor, $1,970.12; fuel, $439.97; subsistence, $548.25; total, $2,958.34. Cost per yard, 3 cents; per linear foot, 31 cents. The grader had a total crew of 17 men, and used about 80 bushels of coal per working day.

March 26 I was transferred to Grader No. 2. This has pumps of the Deane make, and, except in being duplex action, they are of the same general dimensions and steam-power as Grader No. 4.

We again began work on upper Osceola Bar, where we were at work until, April 6, the water again rising obliged us to stop. Here we graded 2,900 linear feet, 10,639 yards. The expense of this period was: Labor, $403; fuel, $83.60; subsistence, $83.20; total, $569.80. Cost per yard, 3.8 cents; per linear foot, 14 cents.

We were laid up on account of high water until July 14, when I was directed to take Grader No. 4 and try to wash a channel through the bar forming from near the head of Bullerton toward the head of Yankee Bar. We commenced on the lower side of the bar, working up-stream with two 1½-inch nozzles, which were fastened to a spar and lowered to the bottom. Soundings showed that a hole was readily washed from 3 to 5 feet deep, but that it filled up immediately after the grader moved. There were then 17 feet of water on the bar. We also tried working from the upper side of the bar down, but in each case the hole filled up almost immediately. July 24 this was given up, it being evident that the work was useless.

July 28 we began grading again on Bullerton below the previous work. August 30, run out at lower end of the tow-head, making 4,360 linear feet, 36,606 yards. Most of this time we could use but one pump. The cost of this period was: Labor, $840.50; fuel, $199.90; subsistence, $173.80; total, $1,214.20. Cost per yard, 3.3 cents; per linear foot, 27 cents. This was the last grading performed by me. September 24 I was again transferred to Grader No. 2 and directed to work in the chute below Gold Dust. September 26 the grader sunk while passing down the chute. The circumstances were related in my report of the occurrence. The grader was raised October 14.

I have thus given a sketch of the amount of work performed by the graders, most of the work being done by No. 4. I can say very little as to the respective merits of the Davidson and Deane pumps. The advantage seems to be with the Deane for regularity of action and their greater solidity acquired by the iron beds and the heavier metal of its parts.

The arrangement of the wells under the pumps was found to give trouble by the pumps sucking the sand and muddy water running off the banks, wearing the packing and plungers. While laid up during May and June this was changed so that the water is now taken from the bow or the point where, as the grader lies to the bank at work, it is over the deepest water and removed as far as possible from the effect of the mud from the bank. The wells in the bow seem to act as a settling tank and furnish better water to the boilers and pumps, but they require to be frequently cleaned of the mud deposited.

The left pump of Grader No. 4 seemed to have settled out of line, so that during August we could use but one pump. An examination also showed that part of the valve motion had become so worn that it was probably the cause of the irregularity of stroke and heavy pounding for some time noticed in this pump. The rubber valves seem to wear rapidly. Two sets have been used. The worn valves have been refaced in a lathe, but after being so faced have proved to be of very little further use.

In working the grader I have generally used one 1¾-inch nozzle with two 1¼ inch. One large nozzle proves to be more effective than two small ones, but the small ones make the better grade. There seems to be too much water flowing in one place from the large nozzle. When using all, I have had the small nozzles working together near the grader, with the large nozzle about 100 feet ahead in a cut by itself. Occasionally a stratum of hard blue clay is found which the smaller nozzles cannot cut, and I have then combined all. The general arrangement of strata has been, on the top a brown clay from four to twelve feet thick, with underlying strata of sand alternating with clay; but these strata occur in great variety of number and thickness. When the bank is entirely of clay but little care need be taken for a smooth grade. Where sand occurs the method I have used has been to keep the top of the cut a little ahead of the bottom, and always keeping enough of the loose soil back of the cut to form a sluice and prevent the water flowing back over the grade. A gully will be formed at the bottom, but, if properly managed, this can be filled by the caving of the bluff, and the sluice advanced as rapidly as possible. The proper grade should be made at the first cut; any trimming afterward generally does harm. In some sandy places the only way we could prevent gullies was to throw the water from the top of the grade down; then the jet after cutting does not run down the grade, but glances off into the river.

The obstacles encountered are logs buried in the bank, stumps, the willow especially going deep, willow brush growing thickly with long roots; these form a mat which the jet will not penetrate, and must be cut and pulled out. When practicable, I have left stumps standing on the grade; otherwise they are pulled out by the hoisting engine of the grader. In freezing weather ice forms a few inches thick on the surface of the bank, and finally falls in a sheet over the bank to be cut. The jet will not cut this ice; so it has to be broken and moved by hand.

The small nozzles are strapped or fastened with hook-bolts to a lever or bar held by the nozzleman; to this lever is fastened a stem allowing vertical motion to the nozzle. This stem is inserted in a pipe, which, being pointed, is driven into the ground as a stand. The stem is held in place by a set-screw, which penetrates into a recess in the stem and allows free horizontal motion. The stand-pipe is also assisted by an anchor placed forward. The anchors were first made with a rigid bar at right angles to the fluke; this bar had a hook at the end, which was put in a ring on the stand; but as they invariably soon broke at the angle between the fluke and the bar, I substituted a chain for the bar. For the large nozzles I at first tried the same kind of stand, but soon found it would not hold even with three anchors; therefore a heavy wooden bench having four legs was made; this has worked well, requiring two anchors. The large nozzles furnished gave way at the base by the copper tube drawing out of the coupling ring. January 6 this occurred, breaking the nozzleman's leg; since then a heavy iron clamp with an eye on one side has been used; the clamp is also riveted to the tube.

For service on the bank I have used one nozzleman and two helpers for the large nozzle, and one nozzleman with one helper for each small nozzle. On the grader we require two engineers, two firemen, a linesman, and helper.

Since April 6, the party has been subsisting on the nearest quarter boat.

To obtain the data necessary to make the reports of the efficiency of the pumps, work performed, &c., the pumps have a "revolution counter" and a scale laid off on the side of the pumps to show the length of the stroke. The steam engineer has on a board placed convenient a blank form (see Form 2), on which he records the exact time of starting and stopping of the pumps, cause of stoppage, and the reading of the revolution counter at time of stopping. The counter is disconnected when the pumps stop, and connected when the pumps are started, after they have made the first few strokes to fill the boom pipe and hose. A record is thus kept of the effective strokes of the pump. The theoretical discharge is computed from the number and length of the strokes. The nozzles also have a pressure gauge at the base where the stream begins to contract, which gauge shows the pressure at this point, and the actual discharge is computed from this pressure according to tables found in "Ellis on Fire Streams." A blank form is fastened up on the grader house, and on it the nozzleman records frequently the pressure of nozzles and pumps at the same time, also the time of observation, length of hose, &c. (see Form No. 4). The steam engineer also makes daily reports (Form 3) of matters pertaining to the working of his engines. From these reports and bank measurements my reports (see Form 1) are compiled.

The efficiency of the water cylinder has varied from 75 to 85 per cent.

The pressures used have generally been about 110 or 115 pounds at the pumps, which gives from 80 to 90 at the nozzles. I at first endeavored to use higher pressure, but the frequent bursting of the 2½-inch hose obliged me to use the low pressure mentioned. This 2½-inch hose was of rubber, 6-ply. The 4-inch hose at first seemed able to endure all the pressure I wished to give, and I had no trouble with it, until after laying up through the high water I tried to use the large hose and nozzles under water washing the bar. Then the hose would not endure more than 80 pounds pump pressure, and this weakness still continued when the hose was used for bank grading. I have cut out the burst places and inserted couplings, but the 4-inch hose on hand is weak and causes delays by its frequent bursting. The 2½-inch rubber hose has mostly been replaced by a cotton rubber-lined hose, Eureka brand. The single 50-foot section furnished me last spring has given good satisfaction, and I believe is still serviceable; but hose of apparently the same kind received since has given much trouble by bursting at very moderate pressure. The first to break gave way at 80 pounds; I had observed the pressure only a moment before it burst. This hose also gives way near the nozzle. The first signs are numerous fine jets issuing all around the hose; these increase in size and number until the hose gives way. The time consumed in replacing coupling, either when the hose has burst or the coupling slipped, has added to the cost of the work. I have endeavored to have sufficient hose on hand so that these repairs could be made at night or at times without interfering with the work, but several times have had to stop and make general repairs. When the cotton hose is not in use, I have kept it on the staging in an inclined and straight position. When in use this hose has no chance to dry, and this may tend to weaken it.

The graders as they are, seem to be very complete for the service, and I have no suggestions to offer as to changes in the general construction. I would only suggest that some arrangement be added that will enable the full power of the pumps to be applied to pumping from the hold in case of accidents or leaks which may endanger the grader.

I append the blank forms used in collecting data for reports.

Very respectfully, yours truly,

S. P. HATFIELD,
United States Assistant Engineer.

Mr. A. J. FRITH,
United States Assistant Engineer in charge Plum Point Reach.

[Form 1.]

TABULAR REPORT.

HYDRAULIC GRADER No. —.

For 10 *days ending* ——— —, ——.

Date.	Linear feet.	Area of cross-section.	Cubic yards.	Time in minutes.								Yards per hour.	Bushels coal.	Travel.	Displacements.					
				Working.				Moving.		Delay.					Total for the day.	Per minute.				
				Each nozzle.			Pumps.	Boat.	Nozzles.	Machinery.	Otherwise.					Nozzles used.				
				1¼"	1½"	1¾"										1¼"	1½"	1¾"		

Pressures.						Nozzles.		Hose.		Discharges.								Efficiency of water cylinder.
Steam.	Vacuum.	Pump.	Nozzle.			Number.	Size.	Size.	Length.	Each nozzle.						Total.		
			1¼"	1½"	1¾"					1¼"		1½"		1¾"				
										Theor.	Act.	Theor.	Act.	Theor.	Act.	Theor.	Actual.	

Cost per diem.					Cost.		Per cent. composition.				Height of bank.	Profile and strata.	Remarks.
Labor.	Fuel.	Subsistence.	Total.		Per yard.	Per linear foot.	Brown clay.	Blue clay.	Sand.	Remarks on stumps and obstructions.			
			Grading.	Other.									

[Form 2.]

STEAM ENGINEER'S REPORT.

Date: ——— —, ——.

Exact time starting.			**Exact time stopping.**			**Reading of counter.**	**Remarks, cause of delays, &c.**
1⅜″	**1¼″**	**1⅛″**	**1⅜″**	**1¼″**	**1⅛″**		

[Form 3.]

STEAM ENGINEER'S DAILY REPORT.

Date: ——— —, ——.

Time of day.	**Pressures.**			**Strokes per minute.**		**Reading of counter.**	**Remarks, time of delays, and cause.**
	Steam.	**Pump.**	**Vacuum.**	**Number.**	**Length.**		

[Form 4.]

NOZZLEMAN'S REPORT.

Date: ——— —, ——.

Time of day.	**Pressures.**				**Length of hose.**			**Remarks, condition of hose, &c.**
	Nozzle.			**Pump.**				
	1⅜″	**1¼″**	**1⅛″**		**4″**	**2½″**		

I 7.

REPORT OF W. H. POWLESS, ASSISTANT ENGINEER, UPON SURVEYS ON THE PLUM POINT REACH.

FULTON, TENN., *November* 5, 1883.

CAPTAIN: In accordance with your order of September 14, I have the honor to submit the following report for the eleven months ending October 31, 1883.

Field and office work.—The following is a statement of the work accomplished by the party:

* * * * * * *

The following additional maps and tracings have been made:

* * * * * * *

Numerous progress sheets have been prepared, and several drawings made of machinery, &c.

The following measurements of discharge have been made:

* * * * * * *

The following miscellaneous field work has been done:

* * * * * * *

Stage of the river.—From the hydrograph which accompanies this report it will be seen that three distinct flood-waves passed down during the eleven months. The heights attained by their crests, and the dates of their passage at Plum Point, are as follows:

Number.	Date.	Height above low water of 1879.	Height below high water of March 1, 1882.
		Feet.	*Feet.*
First	March 1, 1883	32.20	0.52
Second	April 19, 1883	28.80	3.92
Third	June 30, 1883	26.75	5.97

The first flood caused a general overflow between Cairo and Memphis; but as it subsided very rapidly, its effect was less disastrous than that of March 1, 1882. The second and third flood-waves only overflowed the banks in a few localities; the latter was caused by the Missouri River, and did much damage above Cairo.

In accordance with your instructions, the mean stage of the river for the years ending November 1, 1882, and November 1, 1883, was computed, a planimeter being used for the purpose. The results obtained were 20.6 and 14.8 feet, respectively. The following table gives the mean stage for the months comprising those years.

Mean stage of river.

Months.	1881 and 1882.	1882 and 1883.
	Feet.	*Feet.*
November	1881, 17.5	1882, 5.6
December	1881, 18.2	1882, 5.2
January	1882, 28.2	1883, 9.7
February	1882, 31.7	1883, 25.6
March	1882, 31.8	1883, 24.4
April	1882, 24.1	1883, 26.0
May	1882, 25.7	1883, 20.8
June	1882, 26.1	1883, 24.0
July	1882, 22.0	1883, 19.4
August	1882, 11.7	1883, 10.5
September	1882, 8.0	1883, 3.1
October	1882, 4.7	1883, 3.4

The following table is also appended.

Number of days on which the stage of the river varies between—	November 1, 1881, to November 1, 1882.	November 1, 1882, to November 1, 1883.
	Days.	*Days.*
0 and 5 feet....	22	75
5 and 10 feet....	45	88
10 and 15 feet....	46	26
15 and 20 feet....	82	61
20 and 25 feet....	78	42
25 and 30 feet....	84	59
30 and 35 feet....	63	20

CHANGES ON THE REACH.

* * * * * * *

The most striking change noted is the great excess of the fills over the scours, a feature probably due to the February-March flood, the slackening of the current when the water overflowed its banks causing deposits which subsequent floods have as yet failed to remove.

Ashport Bend.—In the bend above Daniels Point rapid caving occurred during medium and high stages, and an unusually swift current existed. (During the February-March flood the surface velocity in this bend, about 300 feet from the caving bank, was 9 feet per second or 6 miles per hour.) The material derived from this caving was probably deposited over the bed of the river in Ashport Bend, where the current was much more slack. This deposit in turn caused a contraction of sectional area from which the river, owing to the curvature of its left bank and the nature of its material, sought relief in caving rather than in bed erosion. Approximate values of the volume of scours and fills in this locality were as follows:

	Cubic feet.
Volume of caving bank in bend above Daniels Point	170,000,000
Volume of caving bank in Ashport Bend	106,700,000
Volume of bed erosion in Ashport Bend.................................	86,000,000
Volume of fill over bed in Ashport Bend	429,200,000

Assuming that the volume of caving in the Ashport Bend has been carried below, the volume deposited in the bed which has been derived above from sources other than the caving bank in the bend above Daniels Point is 152,500,000 cubic feet.

The values of the mean depths, widths, and sectional area at low water are given in a table accompanying this report, and are also represented graphically on a tracing. The following are the mean values in this part of the river.

Mean changes in Ashport Bend, Nos. 20–27, both inclusive.

Decrease in high-water sectional area	square feet..	10,377
Decrease in low-water sectional area	do....	9,056
Decrease in low-water mean depth	feet..	5
Increase in low-water width	do....	218

* * * * * * *

Ranges Nos. 27–31.—The changes over this portion of the river consist in a scour along the main dike and a fill in the channel. The maximum value of the former is 10 feet and its average about 5 feet. The maximum fill, 23 feet, occurs on No. 30.

Main river, Nos. 32–38.—An inspection of Nos. 32 and 33 shows that a very heavy fill has occurred off Elmot Bar, which has been accompanied by marked caving on the Arkansas shore. On No. 33 the area of this fill and caving are nearly equal, but on No. 32 the fill is largely in excess. The caving in this locality has formed a false point below No. 33, the tendency of which is to throw the water toward the foot of Elmot Bar. This effect is particularly noticeable on No. 36.

Elmot Chute.—The changes in this chute are as follows: Over areas behind the old dikes a fill has generally resulted; over areas behind the gaps recently closed a scour has occurred; on Nos. 30 and 31, at Keys Point, a caving bank and a making bar have shifted the channel to the south, while lower down along Elmot Bar, from No. 34 to 37, similar causes have shifted the channel to the north. Below No. 38 the chute has made a new low-water mouth along the outside of Island No. 30, causing very heavy scours. Owing to this and to the caving banks before mentioned, the resultant change in the high-water sectional area shows an increase. The increase in the area of the low-water section is not so marked, owing to the bulk of the erosion occurring above low-water mark.

The following are the values of these changes:

Mean changes in Elmot Chute.

Nos. 27–42, excepting Nos. 28 and 31:

Increase in sectional area, high water	square feet..	3,340
Increase in sectional area, low water	do....	420
Increase in mean depth, low water	feet..	1.1

The upper mouth of Elmot Chute at the foot of Elmot Bar is about the same as during the December–February survey. It filled up completely during the high stage, but cut out again when the river fell.

Chute No. 30.—The closing of this chute at its head, which was commenced in 1881, still continues. It is now entirely cut off at the low stage, and has not been taken into account in computing mean values of low-water areas, &c.

The mean changes in its three cross-sections are as follows:

Decrease in high-water sectional area	square feet..	2,53.00
Decrease in low-water sectional area	do......	710.0
Decrease in low-water mean depth	feet..	0.6

Osceola Chute.—The changes in this chute have been as follows:

Upper Osceola Chute, Nos. 39½, 40, 40½, 41, 41½, 42, *and* 43.

Mean decrease in high-water sectional area	square feet..	4,396.0
Mean decrease in low-water sectional area	do......	946.0
Mean decrease in low-water mean depth	feet..	1.9

The maximum fill, 17½ feet, occurs on range 42.

Lower Osceola Chute, Nos. 45–47.

Mean increase in low-water sectional area	square feet..	40

Main River, Nos. 37–50.—On this portion of the river the most noticeable change is the continued caving along Osceola Bar, extending from Nos. 41–47, and tending to shift the channel still further toward the Arkansas shore. The closing of chute No. 30 at low stages, and the deepening of the lower mouth of Elmot Chute, have caused a marked shoaling (maximum value, 44 feet on No. 42) of the old channel, and a scouring along the Tennessee shore, against which the water from Elmot Chute impinges. This water is there deflected and then scours the old channel at No. 44, and thereby causes the fill in the locality where the Government fleet formerly lay. It also appears that a shoaling of 22 feet has occurred at the Plum Point Landing (No. 45). At No. 48, a fill averaging 16.4 feet has occurred for a distance of 2,400 feet, in front of the Osceola–Bullerton Dike, while a marked scour has taken place in the channel. Behind this dike a fill averaging 10 feet in depth has occurred on No. 48 for a distance of 700 feet, and on No. 49 a fill averaging 10.6 feet extends to the Arkansas shore.

Main river, No. 50, *to head of Yankee Bar.*

On No. 50 a scour has occurred on the upper side of Bullerton; shoal water still continues along the outside of Bullerton Tow-head off its head, but a channel has scoured out about 1,200 feet from it, giving 10 feet at low water down this passage. Below No. 50 a fill has generally occurred over Bullerton Bar, except on range 56, where a scour has taken place, owing to the recession of the bluff sand-bank which forms the right shore of the Tennessee Chute, below No. 55. A marked scour has occurred off the outside of Bullerton Tow-head, at No. 52 and 53, and a deepening has also taken place at its foot. This latter change is not shown on the tracings; it occurred between the surveys of August and October, and amounted to 3 feet.

Bullerton Chute.—The following show the mean changes in Nos. 50, 51, 52, and 53, in this chute:

	Square feet.
Increase in high-water sectional area	1,212
Increase in low-water sectional area	1,481

Below head of Yankee Bar.—Below Range 58 the changes are not very marked. Owing to high water caving, No. 58, which formerly crossed Yankee Bar, now passes above it. Caving still continues above Craighead Point.

Yankee Bar Chute.—No data exists for noting the changes in this locality. Appearances, however, indicate a fill throughout its whole extent.

Changes in Elmot and Island No. 30 *chutes between surveys of April,* 1882, *and September–October,* 1883.

The surveys of April, 1882, being made before the dikes were commenced, this comparison gives an idea of the changes caused by them. The caving of the banks at Key's Point and Elmot Bar and the deepening of the chute below No. 38 had begun several years before the dikes were commenced, and their erection has not as yet caused any changes in these localities. The shoaling of the chute of No. 30 at its head is of several years' standing, and still continues.

On a tracing the dikes are shown as they existed about August 1, as the gaps in them which have very lately been closed must have influenced greatly the changes which have occurred. These changes are very similar to those already noted above as occurring between the surveys of December–February, 1882–3, and October, 1883. On No. 31, outside of the dike, a fill is shown, but the former comparison shows that this has since been scoured away.

The mean changes which have occurred in these chutes are as follows:

Increase in high-water sectional area	square feet..	1,273
Decrease in low-water sectional area	do......	557
Increase in low-water width	feet..	106
Decrease in low-water mean depth	do ..	0.1

An approximate value of the excess of the volume of scour over that of fill between the high-water sections, from 28 to 42, is 22,426,000 cubic feet.

Gauging observations.—Gauging observations have been made with double floats, run at mid-depth and observed from the end of a base-line several hundred feet long. An ordinary watch was used for observing time. The distance over which the passage of floats was observed was 200 feet.

The computed discharges mentioned in the table of results given below (Appendix) have been computed from the equation of the Fulton discharge curve given in my report of July 11, 1881, to the Commission. The observed values of the discharge of the river at Bullerton Tow-head on September 5 and October 26 differ from those computed by 3¼ and 1 per cent., respectively.

It will be seen that the discharge in Lower Osceola Chute ceases at a stage of about 4 feet; at a stage of 25 feet it passes about 7 per cent. of the volume of the river. The observations taken in Elmot Chute show that in June the upper mouth discharged about one-half more than the lower mouth, but that in October these discharges were about equal. The discharge of Chute 30 ceases at about a 6-foot stage.

The ratio of the discharge of Bullerton Chute to the entire discharge of the river varies inversely as the stage. On September 15 (stage 4.9 feet) its value was 0.62; on October 26 (stage 5.4 feet) this was reduced to 0.50, owing to a scouring, both in the Tennessee and middle channels.

SLOPE OBSERVATIONS.

A table accompanying this report gives a comparison of the profiles of the river on March 1, 1882, on which date it reached the highest level on record, and on October 12, 1883, when the stage at Elmot was 3 feet above low water of 1879. It will be seen that the value of the fall from Ashport to Fulton is 1.36 feet greater at the low than at the high stage. This difference is a maximum at Petty's Landing, the fall between that point and Ashport being 3.28 feet greater at the low stage.

The following values of the fall through Bullerton Chute from Driver's to Petty's Landings, are given:

Date.	Above low water at Driver's Landing.	Fall.
	Feet.	*Feet.*
March 1, 1882	33.0	0.68
October 12, 1883	2.1	2.52
November —, 1879	0.2	3.27

From the tracing showing the two profiles, it is seen that the excessively high slope in the vicinity of Bullerton Tow-head is accompanied by a low value of the curve of mean depth; also, that a marked scour has occurred in the locality where at the high-water of March 1, 1882, a very heavy slope was found.

During the low-water surveys of August–September, 1883, and October, 1883, great variations were found in the level of the water at the opposite extremities of the cross-sections in the vicinity of Bullerton Tow-head, caused doubtless by a shoal at the lower end of the Tennessee Chute, acting as as a dam and forcing back the water.

On October 22 the following differences in elevation were found:

	Feet.
Elevation of No. 50 Tennessee above No. 50 Arkansas	0.62
Elevation of No. 51 Tennessee above No. 51 Arkansas	1.33
Elevation of No. 53 Tennessee above No. 53 Arkansas	1.62
Elevation of No. 54 Tennessee above No. 54 Arkansas	1.73
Elevation of No. 58 Tennessee above No. 58 Arkansas	1.78

An erosion is now occurring at this shoal in the chute, the effect of which will be to lessen the above differences and increase the discharge.

CAVING BANKS.

Ashport Bend.—The length of the caving bank in this bend is about 14,000 feet, extending from No. 21 to 26, and the greatest annual rate of caving is at present 540 feet. The caving since the fall of 1879 has amounted to about 700 feet. As far as observed, caving here occurs wholly at medium and high stages.

Below Fletcher's.—Caving here extends from the mouth of Mill Bayou to the false point below No. 33, a distance of 8,000 feet; of late, however, but little caving has occurred above No. 32. The maximum caving now occurs at No. 33, where the annual rate is 600 feet.

Inside of Elmot Bar.—Below No. 34 the caving which was in progress in 1879 still actively continues, and to it is due the erosion of the lower mouth of Elmot Chute and the closure of Chute No. 30 at its head. The length of the caving is about 5,000 feet, and the present maximum rate is 360 feet per year.

Outside of Osceola Bar.—The caving in this locality has been in progress since 1879, since which date the head has receded down-stream 3,000 feet, and the cut now known as the middle entrance formed. The caving since 1879 has been 1,600 feet at No. 41, and 700 at No. 44. The maximum caving of late has been at No. 44, where the bank has receded 250 feet in ten months. At present no caving is occurring in the locality, the bank having been revetted.

Below San Souci.—Caving still continues in this locality and is most marked at the low stage owing to the swift current in Bullerton Chute. The length of the caving bank is about 3,700 feet, and its present maximum rate 270 feet per annum.

At and above Craighead Point.—This caving occurs almost entirely at medium and high stages. Its length is about 15,000 feet extending from No. 56 to No. 68. The maximum rate is about 260 feet per year.

Head of Yankee Bar.—At high stages a very swift current was thrown against the head of Yankee Bar, due probably to heavy fills in Yankee Bar Chute. The bank being composed of sand has receded very rapidly, the amount of recession being 1,200 feet from January to October, 1883.

Local high-water caving has occurred at Keys Point, left bank of Chute No. 30, and Tennessee shore below Plum Point.

* * * * * * *

SUMMARY OF CHANGES ON THE REACH.

The following table exhibits the mean values of cross-section areas, &c., from Daniels Point to Fort Pillow. In all computations relating to low-water dimensions, the following chutes in which no current exists at low water have been disregarded.

Ashport, Osceola, No. 30, and Yankee Bar.

Mean values No. 17 to 71.

(These volumes have been measured with a planimeter from curves shown on tracing.)

Decrease in high-water sectional area	square feet	4,438
Decrease in low-water sectional area	do	4,728
Decrease in low-water mean depth	feet	0.9
Decrease in low-water width	do	109
Area in low-water sections December, 1882, February, 1883	square feet	49,520
Area in low-water sections October, 1883	do	44,792
Low-water mean depth December, 1882, February, 1883	feet	15.4
Low-water mean depth October, 1883	do	14.5
Low-water width December, 1882, February, 1883	do	3,308
Low-water width October, 1883	do	3,199

The value of the decrease in high-water sectional area would be probably materially increased if the fills in Ashport and Yankee Bar Chutes had been ascertained. This omission, however, has not effected the values for the low-water sections.

The following is a summary of the volumes of fills and scours over the reach, between the surveys of December, 1882, February, 1883, and October, 1883.

	Feet.
Volume of fill below ordinary high-water mark	726,500,000
Volume of fill below low-water mark	655,000,000
Volume of fill above low-water mark	70,700,000
Volume of scour below ordinary high-water mark	257,900,000
Volume of scour below low-water mark	142,500,000
Volume of scour above low-water mark	115,400,000

* * * * * * *

My assistants, Messrs. Phillips, Maurer, and Clark have rendered valuable and efficient service.

Respectfully submitted.

W. H. Powless,
Assistant Engineer.

J. G. D. Knight,
Captain of Engineers, U. S. A.

Results of gauging observations.

Locality.	Date.	Elmot gauge.	Area at cross sections.	Mean depth.	Mean velocity.	Maximum mid depth velocity.	Observed discharge.	Ratio of observed discharge to computed discharge of entire river.
	1883.	*Feet.*	*Sq. feet.*	*Feet.*	*Ft. per sec.*	*Ft. per sec.*	*Cu. ft. per sec.*	
Elmot Chute at Range 38	June 27	26.60	75,781.5	21.9	4.70	5.90	357,051.4	0.370
	July 18	17.00	49,150.0	16.1	4.00	4.55	196,261.0	0.356
	Oct. 11	2.69	....	....	....	....	22,892.0	0.140
Elmot Chute at foot of Elmot Bar	June 25	26.50	....	....	....	....	215,381.4	0.220
	July 18	17.00	....	....	....	....	97.675.0	0.182
	Sept. 20	2.00	2,978.0	6.4	3.71	4.09	11,028.0	0.069
	Oct. 11	2.69	3,570.0	6.6	3.20	3.70	11,592.0	0.071
Elmot Chute, lower mouth, at Range 39	June 25	26.50	28,154.1	28.4	5.0	5.26	141,670.0	0.150
	July 19	17.55	20,581.1	22.8	4.8	5.55	98,586.0	0.174
	Sept. 20	1.95	5,100.0	6.1	1.76	2.17	8,984.0	0.074
	Oct. 11	2.70	5,400.0	6.5	2.09	2.70	11,300.0	0.069
Small chute opposite towhead on Range 38	June 26	26.60	9,136.0	15.8	3.80	4.20	35,077.0	0.040
	July 18	17.00	3,761.0	7.2	3.80	5.71	14,344.0	0.020
	Sept. 20	1.95	....	....	....	....	0	....
	Oct. 11	2.70	....	....	....	....	0	....
Chute No. 30	June 26	26.60	....	....	....	....	159,824.7	0.190
	July 18	17.00	....	....	....	....	57,850.2	0.105
	Sept. 20	1.95	....	....	....	....	0	....
	Oct. 11	2.70	....	....	....	....	0	....
Osceola Chute at Range 41	July 5	25.80	21,449.0	17.8	1.2	1.8	26,545.2	0.028
Osceola Chute, Range 42, Arkansas shore	July 5	25.80	8,562.0	14.9	1.57	2.00	13,552.6	0.013
Osceola Chute, Range 45	May 10	28.30	16,856.8	21.6	3.60	4.20	59,074.5	0.070
	July 5	25.80	16,687.0	20.2	4.00	4.60	65,671.8	0.071
	July 17	16.60	9,000.0	18.2	3.12	3.60	28,148.0	0.053
Osceola Chute, Range 48	Sept. 5	4.95	3,364.0	8.2	0.36	0.45	1,211.0	0.006
Bullerton Chute at Range 53	May 10	28.30	42,180 5	40.9	4.60	5.35	194,774.4	0.240
	July 17	16.60	35,924.0	37.2	5.02	5.80	182,235.0	0.337
	Sept. 5	4.95	24,688.0	25.5	5.10	7.00	126,431.0	0.020
	Oct. 26	5.35	24,050.0	23.4	4.48	5.27	107,711.0	0.505
Middle Channel, Range 53	Sept. 5	4.95	18,700.0	9.2	2.80	3.71	52,238.0	0.265
	Oct. 26	5.35	18,600.0	8.6	3.54	4.82	65,875.0	0.306
Tennessee Chute, Range 53	Sept. 5	4.95	10,400.0	7.7	2.50	3.13	25,502.0	0.126
	Oct. 26	5.35	12.050.0	8.5	3.34	4.50	40,255.0	0.180

Discharge of entire river at Range 53.

Date.	Elmot gauge.	Above low water at Fulton.	Sectional area.	Width.	Mean depth.	Mean velocity.	Observed discharge.	Computed discharge.	Difference.
	Feet.	*Feet.*	*Sq. feet.*	*Feet.*	*Feet.*	*Ft. per sec.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*	*Cu. ft. per sec.*
Sept. 5, 1883	4.95	6.21	53,788	4,345	12.3	3.7	204,100.0	211,700	7,600
Oct. 26, 1883.	5.35	6.24	54,700	4,618	11.8	3.8	213,841.0	211,724	2,117

On September 5 the river was falling. On October 26 the river was stationary.

APPENDIX K.

REPORT OF MAJOR A. M. MILLER, CORPS OF ENGINEERS, UPON OPERATIONS IN THE SECOND DISTRICT, MISSISSIPPI RIVER.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., November 12, 1883.

COLONEL: In compliance with your letter dated September 6, 1883, I have the honor to submit the following report of work done since December 1, 1882, in the second district, under the supervision of the Mississippi River Commission.

MEMPHIS REACH AND HARBOR.

Bank protection.

In November, 1882, a project was submitted for work on the Memphis Reach, from foot of Island No. 40 to Scanlan's Landing, and the revetment of the bank in Hopefield Bend on the west bank, and from Frame's Chute to mouth of Wolf River on the east bank, was approved by the Commission, an allotment of $600,000 having been made for this purpose, and at a subsequent meeting of the Commission, on my urgent representation, an additional allotment of $25,000 was made for the purpose of revetting and securing the bank on the Memphis front, from the freight elevator to mouth of Wolf River, where caving seriously threatened great damage and the probable entire destruction of very valuable mills, the cotton compress, and freight elevators.

MEMPHIS FRONT, BELOW WOLF RIVER.

The work of sinking mattresses was nearly completed on December 1, 1882; since that date five mattresses were sunk, three in the vicinity of the cotton compress, and two in front of the city levee, as shown on map. The upper bank was graded by hand, from the elevator to cotton compress and revetted with willows and broken stone. In addition to the revetment of the bank it was necessary to build wooden culverts to lead the city drainage to low water, in order to prevent its cutting the bank into gullies, and thus causing fresh caving.

The amount of work completed here was as follows: Five mattresses 60 by 120 feet = 300 linear feet; 13,700 cubic yards bank excavation; 362 feet wooden culverts 2 by 2 feet; 6,273 square yards of upper bank revetment.

This work has apparently accomplished the object for which it was constructed, that is, the prevention of further bank caving. It has stood well the high water of 1883, and quite a growth of willows has made its appearance on the upper bank revetment. Some repairs may be necessary from time to time to keep the culverts in order.

REVETMENT OF HOPEFIELD BEND.

This work consisted in sinking deep-water mattresses, building upper bank protection, and the grading of bank above low water. The object of the work is to hold the river in its present channel, thus preventing a possible cut-off, which would leave the city of Memphis away from the river.

The project contemplated the revetment of the bank from Mound City Landing above, for a distance of two miles, to a point in the vicinity of Hopefield.

Active operations were begun in December, 1882, by the employment of hydraulic grader No. 2, in grading the bank and mattress sinking, which was continued until February 10, 1883, when high water put a stop to the work. Owing to the condition of the river during the sinking of mattress work, rapidly rising water, much difficulty was experienced from drift and a strong current, it was therefore not considered safe to construct continuous mats. The mattresses were therefore sunk in lengths varying from 250 to 300 feet, all having a width of 140 feet.

On February 10, 1883, high water caused a suspension of the work, at which time 1,127 linear feet of mattress 140 feet wide had been placed in position.

Work was resumed in August, 1883, and is still in progress.

The total amount of work done since December 1, 1882, to October 31, 1883, has been as follows: 6,956 linear feet of mattress 140 feet wide made and sunk; 7,529 linear feet of mattress 140 feet wide made; 67,242 cubic yards of bank-grading; 6,663.5 cords of willows cut and delivered; 415 cords of poles cut and delivered; 4,922.25 square yards of upper-bank protection made.

In addition, snagging, bank clearing, and repairs were carried on, for details of which reference is made to the report of Mr. W. M. Rees, assistant engineer (marked B), forwarded herewith, whose diligence and tact in immediate charge of the work has been of great value.

The portion of the bank revetment 1,127 linear feet, built December, 1882, to February, 1883, and which has experienced the effects of the high water of 1883, when the water was 5 feet over the banks at the point revetted, has shown good stability. After the water fell a small cave occurred, owing to a want of continuity of the mattresses, which was rectified by placing a mattress over the vacant spot. The upper end or head of the mattress work will require some additional work to secure it, but in its present condition is secure from serious damage. The effect of the next high water upon this work is looked forward to with great interest, as it will probably decide many points in this method of protection. It does not apper to be advisable to undertake this kind of work until the water has nearly if not quite reached its lowest stage, although this depends somewhat on the depth of water at the bank to be revetted. At high water it has been found very difficult to place the mats in proper position, as the tendency is to slide or run up against the bank, thus resulting in upper bank protection, when it is essential that the lower bank should first be held. The principal cause of delay in the work has been difficulty in procuring willows. During low water, when it is absolutely essential to push the work as rapidly as possible, the very worst conditions obtain in reference to procuring willows; that is, they must be hauled quite a distance to get them on the barges. This is the principal item in their cost. The practice on this reach has been to build wooden tramways and cars and haul them by mules. It is not possible to obtain willows at high water, and keep them on hand for use, as they must be fresh, or are so brittle as to be useless for weaving. Delay from lack of stone has not been felt very seriously on this work, as the amount required has been comparatively small; on one occasion recourse was had to sacks filled with buckshot clay to sink a mattress, and the work seems to have held well; 4,300 gunny sacks were used at a cost, and loaded on barges, filled, of about $387; their weight was equal to about 214 cubic yards of stone.

Labor has been plentiful, but difficult to keep employed on account of the unhealthy climate. White labor has been employed with the exception of one willow party, which was composed of negroes with white overseers. They gave better satisfaction cutting willows than white labor, but were more difficult to keep, as when a week's wages were due them they would quite generally leave and lay idle till their wages were spent.

The report of Assistant Engineer Joseph Burney (Appendix K 1) showing all the work done on Memphis Harbor is transmitted herewith.

REPAIR OF LEVEES, YAZOO FRONT.

The Board of Engineers convened by Special Orders No. 88, Headquarters Corps of Engineers, Washington, D. C., August 29, 1882, for the transaction of certain business connected with the repair and building of levees on the Mississippi River, opened bids for the construction and repair of levees September 25, 1882, and a further letting was made on October 16, 1882. The following are the abstracts of bids for repairs of levees in the second district of the Mississippi River Improvement.

Abstract of bids opened September 25, 1882.

No. of proposal.	Names of bidders.	Locality of levee.	Price per cubic yard.	Price of felling timber.	Remarks.
4B	R. G. Huston, Cincinnati, Ohio, John B. Neely, Chattanooga, Tenn.	Parker's Enlargement and breaks.	$0.37		
7	J. W. Eldridge, Lake Charles Landing, Miss.	Lake Charles break	30 25	$80 per acre.	Excavation. Embankment.
10	McGavock & Tate, Memphis, Tenn.	Parker's Enlargement and breaks.	32	Cost and 10 per cent.	
20	Wirt Adams, president Mississippi Contract and Improvement Company, Jackson, Miss.	Parker's Enlargement and breaks. Lake Charles break	23 22	(*)	

* Heavy clearing, $48 per acre; light clearing, $36 per acre.

NOTE.—Contracts were awarded to McGavock and Tate for Parker's Enlargement and breaks, and to J. W. Eldridge for Lake Charles break, Wirt Adams having declined on account of decision refusing employment of convict labor.

Abstract of bids opened October 16, 1882.

No. of proposal.	Names of bidders.	Locality of levee.	Price per cubic yard.	Price of felling timber per acre.	Remarks.
1	Patrick F. Lamb, Bolivar County, Mississippi.	Bland's Bayou to Garland's.	$0 25½ 28	$75 00 75 00	Embankment. Excavation.
2	W. M. Forrest and J. T. Stanton, Memphis, Tenn.	Garth's break to Jefferson's.	22½ 27½ 24½	50 00 50 00 50 00	Jefferson break. Beard break. McCloud break.
3	Arnold & Co., Memphis, Tenn.	......do	23¾	75 00	
		Bland's Bayou to Garland's	24¾	75 00	
4	McGavock & Tate, Colorado.	Garth's break to Jefferson's.	28	40 00	
		Bland's Bayou to Garland's	28	40 00	
5	Andrew Bodkin, Memphis, Tenn.	Garth's break to Jefferson's.	25	40 00	
		Bland's Bayou to Garland's.	25	40 00	
6	F. Gillooly and John Clancey, Memphis, Tenn.	Garth's break to Jefferson's.	24¾	45 00	
10	Timothy Sullivan, Doniphan, Mo.	......do	22	75 00	

NOTE.—Contracts were awarded to Timothy Sullivan for levee from Garth's break to Jefferson's, and to Arnold & Co. for levee from Bland's Bayou to Garland's, their bids being the lowest.

Work was pushed on these levee repairs, and the following work was completed and paid for:

Locality of levee.	Amount of work done.			Cost.
	Embankment.	Excavation.	Clearing.	
	Cubic yards.	*Cubic yards.*	*Acres.*	
Parker's enlargement	89,322	....	....	$28,583 04
Lake Charles break	38,868	1,061	14.30	11,179 30
Bland's Bayou to Garland	44,800	....	22.83	12,800 25
Garth's break to Jefferson's	86,552	....	45.23	22,554 11
Total	259,542	1,061	82.36	75,116 70

All the contractors completed their work before high water, and final payments were made. Since the completion of the work the levee has broken again at the McCloud break, and should be repaired.

SURVEYS.

A survey of the Memphis Reach was completed February 21, 1883, by Assistant Engineer F. S. Burrowes, whose report (Appendix K 3) is herewith submitted.

A survey of the Helena Reach from Commerce Cut-off to Friar's Point was completed January 27, 1883, by Assistant Engineer F. A. Fisher, whose report is herewith submitted (Appendix B 4).

A survey, reconnaissance, and estimate for repairs of levees in the second district was completed by Assistant Engineer Richard Klemm, whose report is submitted (Appendix K 5).

A low-water survey of the Memphis Reach was made in September, 1883, by Mr. H. S. Jacoby, draughtsman, on which sheet is platted the shore lines and present condition of the work, and which is submitted with this report.

Tables showing detailed statements of expenditure under each allotment from appropriation for Mississippi River in this district, also table showing amount of plant purchased for the Memphis Reach, with cost of same, are transmitted herewith.

Very respectfully, your obedient servant,

A. M MILLER,
Major, Corps of Engineers.

Lieut. Col. C. B. COMSTOCK,
Corps of Engineers, United States Army,
President Mississippi River Commission.

List of floating property bought for use at Memphis Reach and Harbor, with cost of same.

Description.	No.	First cost.	Total cost.	Remarks.
Barges	18	$2,000 00	$36,000 00	
Do	3	1,960 00	5,880 00	
Total	21		41,880 00	
Mattress-boats	2	6,000 00	12,000 00	
Screen-boats	4	1,500 00	6,000 00	
Total	6		18,000 00	
Quarter-boats	1	1,980 00	1,980 00	
Do	1	1,840 00	1,840 00	
Do	1	2,741 00	2,741 00	
Do	1	2,376 00	2,376 00	
Total	4		8,937 00	
Pile-drivers	8	4,518 01	36,144 08	
Machine-shop boat	1	8,501 25	8,501 25	$2,380 paid prior to December 1, 1882.
Skiffs	30	22 00	660 00	
Total cost			114,122 33	

NOTE.—Cost of machine-shop boat includes outfit of tools.

A. M. MILLER,
Major, Corps of Engineers.

DETAILED STATEMENT OF EXPENDITURES FOR MEMPHIS REACH AND HARBOR.

August 2, 1882. Allotment	$325,000 00
November 1, 1883. Amount expended for—	
Labor	60,987 73
Material	7,763 50
Supplies	2,469 20
Repairs	1,367 53
Outfit	5,967 82
Assistant engineers	5,711 67
Clerk	1,000 00
Stationery	160 40

November 1, 1883. Amount expended for—		
	Freight	$168 85
	Traveling expenses	222 83
	Office rent	181 00
	Fuel	497 80
	Telegrams	11 63
	Subsistence	16,181 93
	Hire of plant	3,198 91
	Total	105,890 80

A. M. MILLER,
Major, Corps of Engineers.

DETAILED STATEMENT OF EXPENDITURES FOR CONSTRUCTION AND REPAIR OF LEVEES, YAZOO FRONT.

August 2, 1882.	Allotment	$80,950 00
November 1, 1883. Amount expended for—		
	Earthwork	75,116 70
	Labor	1,499 33
	Material	138 00
	Supplies	3 30
	Outfit	8 75
	Assistant engineers	1,600 00
	Clerk	175 00
	Inspector	600 00
	Stationery	8 25
	Traveling expenses	267 95
	Office rent and quarters	108 50
	Telegrams	50 41
	Subsistence	36 00
	Advertising and printing	220 06
	Total	79,832 25

A. M. MILLER,
Major, Corps of Engineers.

DETAILED STATEMENT OF EXPENDITURES FOR SURVEY OF THE HELENA REACH.

August 2, 1882.	Allotment	$8,000 00
November 1, 1883. Amount expended for—		
	Labor	$3,635 66
	Material	41 08
	Supplies	58 66
	Repairs	6 00
	Outfit	607 65
	Assistant engineer	1,205 00
	Clerk	175 00
	Draughtsman	750 00
	Stationery	18 85
	Freight	29 65
	Office rent and quarters	193 00
	Subsistence	562 74
	Hire of plant	228 00
	Total	7,511 29

A. M. MILLER,
Major, Corps of Engineers.

DETAILED STATEMENT OF EXPENDITURES FOR SURVEY OF SAINT FRANCIS FRONT.

August 2, 1882. Allotment		$4,000 00
November 1, 1883. Amount expended for—		
Labor	$670 50	
Supplies	61 34	
Outfit	590 00	
Assistant engineer	880 00	
Clerk	300 00	
Stationery	19 75	
Freight	93 17	
Traveling expenses	106 50	
Office rent	66 00	
Subsistence	305 67	
Hire of plant	120 00	
Total		$3,212 93

A. M. MILLER,
Major, Corps of Engineers.

K 1.

REPORT OF JOSEPH BURNEY, ASSISTANT ENGINEER, ON OPERATIONS FOR IMPROVING THE HARBOR OF MEMPHIS.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., June 30, 1883.

MAJOR: I have the honor to submit my annual report of operations for improving Memphis River Front, for the year ending June 30, 1883. I was instructed by you to take local charge of the work in October, 1882. An examination of the mattress work under water was made by an experienced diver, and the mattress work was found in a fair condition, from the mouth of Wolf River to the foot of Jefferson Street, with the exception of portions of the front near the cotton-shed, Panola oil mill, and Messrs. Brown & Jones' coal-yard. Considerable difficulty had been found with this portion of the bank, on account of the numerous springs and public and private drains keeping the bank continually wet and very susceptible to wash away by the steamboat waves.

In submitting a project, it was recommended that this portion of the bank should be repaired by mattress work, and the whole of the upper bank, from Wolf River to the elevator, be graded to a slope of 3 to 1, where it could be done without injury to the property on the bank, and the bank thoroughly drained, the drains being carried out to extreme low water. It was estimated that this work would cost $25,000. October 18, 1882, active operations commenced; the tug Tilda was chartered, the quarter-boat fitted up, and a working party sent about 25 miles up the river to obtain cottonwood poles and willow brush. Mattress-ways and workmen's quarters were constructed near the foot of Old Hen Island, and on October 28 the first mattress was sunk in front of the lower landing of the cotton-shed. Two mats were sunk at this location; three in front of the Panola oil mills; thirteen were sunk from Brown & Jones' coal-yard to the elevator, and, by request of the city authorities, two were sunk in front of Court street. Each of the mats sunk was 120 by 60 by 2 feet.

Experience in the work shows that it is much better to reduce the thickness of mattress and greatly increase it in length and breadth; but on this portion of the river front this cannot be done, for it requires the taking possession of a large portion of the river front and holding it for some time, thus preventing the steamboats from using the bank for a landing. We are generally at work during the busy season, and steamboat-owners will not permit us to keep them from the bank, nor will the city authorities give us possession of it. We are compelled to construct our mats some distance up the river, float them down to their position, and sink them. This does not interfere much with the steamboats, but it is a very great inconvenience and expense to the work, and the bank protected is not done in such a substantial manner as if the matresses were constructed in long lengths in the location where they are to be sunk.

After the mattresses were all sunk, work was commenced grading the bank; this work was intended to be done with the steam hydraulic grader; but, in consequence of the number of steamboats and other floating property using the bank and the number of buildings upon it, it would have been very inconvenient and attended with difficulty; so you directed the work should be done by laborers with pick and shovel. This is very expensive, as the earth has to be handled so often to get it into the river. Fortunately, the river commenced rising and we just kept our work above it, which did not require so much labor as if the water had been at a low stage.

After grading the bank we connected all the public and private drains and carried them out to low water by means of wooden culverts. We then laid wire upon the graded bank, 6 feet apart along the river bank, and 6 feet apart up the bank; upon this wire we placed willow brush 6 inches thick, and then, on top of brush, we placed wire same as below, and secured same to the lower line of wire by connecting wires, through the brush, so that along the upper bank it formed one large mattress.

This work was done from the mouth of Wolf River to the elevator, with the exception of a portion of the bank in navy-yard, 242 by 32 feet, and a portion, 200 by 30 feet, in front of Brown & Jones' coal-yard. After the willows were secured to the bank they were well ballasted with stone, sand-bags and earthwork. This completed the work in a substantial manner, with the exception of the work noted and within the amount estimated.

Operations were suspended February, 1883, and the plant and outfit turned over to the Hopefield Bend works.

During the time we were at work we had very favorable weather and the river was at a good working stage; but we had considerable trouble to contend with, for want of a sufficient number of flat-boats, and considerable delay was experienced for want of stone.

Immediately after the suspension of operations the river rose and covered the whole of the work, the gauge reading 34.75. Shortly afterwards the water fell to 18.20, when an examination of the bank was made and the work was all found to be in good condition, not the slighest sign of a break or crack in the bank appearing.

SUMMARY OF WORK DONE DURING SEASON.

20 mattresses sunk, 120 by 60 by 2 feet.
6,273 square yards of willow brush shore protection.
13,700 cubic yards of excavation on bank.
362 feet of wooden culverts, 2 by 2 feet, built.

AMOUNT OF MATERIAL EXPENDED.

2,886 cords of willow brush.
5,050 cords of cottonwood poles.
700 oak pins, 4 feet long by 1 inch diameter.
2,100 oak pins, 1 foot long by ¾ inch diameter.
2,750-½ inch carriage bolts.
2,900 pounds wire.
850 pounds rope.
1,086 cubic yards stone.
200 sand-bags.
85 cubic yards cypress bark.
3,164 feet of cypress lumber.
72 feet of 6-inch stone pipe.

I have the honor to remain, very respectfully,

JOSEPH BURNEY,
Assistant Engineer.

Maj. A. M. MILLER,
Corps of Engineers, U. S. A.

K 2.

REPORT OF W. M. REES, ASSISTANT ENGINEER, UPON IMPROVEMENT OF MISSISSIPPI RIVER AT HOPEFIELD BEND.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., November 1, 1883.

MAJOR: In accordance with your verbal instructions, I have the honor to submit a report of operations for the improvement of the Mississippi River at Hopefield Bend, Memphis Reach, from December 1, 1882, to October 31, 1883.

The object of this work is to prevent the caving of the bank, now rapidly taking place, and which threatens injury to the harbor of Memphis.

A comparison of the survey of September, 1883, with that of December, 1877, shows that the bank in the middle of the bend has receded 1,500 feet. From August, 1882, to September, 1883, the caving was 300 feet in the middle of the bend, and near the foot, just above Hopefield, it was 450 feet. The distance across the neck of land to the river below is now about 13,000 feet. To arrest this caving the project is to revet the bank with brush mattresses, these mattresses to cover the bank from the foot of the slope to or near the top, and to be held in place by stone evenly distributed over them.

The method of operations comprised three parts:

1st. The revetment of that portion of the bank below the water surface called deep-water mattresses.

2d. The revetment of the bank above the water surface, called shore protection.

3d. The grading of the bank above the water surface to a suitable slope to receive the shore protection.

METHODS OF CONSTRUCTION.

DEEP-WATER MATTRESSES.

These were built on a mattress barge, 160 feet long by 30 feet wide, upon which were placed 18 skids or runways, 8 feet apart, these skids having an inclination of 3 inches to one foot.

The mattresses made, were the ordinary wattled kind, of brush and poles, similar to those used at the works below Saint Louis, Mo., and at Plum Point, having cottonwood or willow poles 26 to 28 feet long, of diameters not less than 3 inches at the smaller end, nor more than 6 inches at the larger, with brush not less than 24 feet long and two inches in diameter at the butts.

The poles were well spliced together with spikes and wire, one pole being placed alongside each skid. Around these poles, or weavers, the brush was woven and secured by nails and wire. As these mattresses were to be sunk in deep water, from 40 to 70 feet deep, and in a strong current, other poles, called binders, were placed over the weaving poles, well wired to them and spliced together. These strengthened the mattress longitudinally and prevented the stone from rolling off when sunk.

When short brush was used, in order to strengthen the mattress transversely, poles were placed in the direction of the brush, over the top longitudinals, and wired to them, and the weaving poles at their intersections. They were spaced from 8 to 40 feet apart according to circumstances.

The up-river end of the mattress was held to a mooring barge by ten 1-inch diameter ropes. Two ropes 1½ or 2 inches in diameter were securely fastened to the mattress by means of a pin and shackle and led to "dead-men" or trees on shore; both ropes passed under the mooring barge, which was also secured by two or more large lines leading to the shore.

On sinking, a barge of stone was placed along the outer edge of the mattress, run-ways of plank were placed from this, on and over the mattress, and the stone evenly distributed thereon. About half of the stone used on the mattress was placed in this manner. More stone from the mooring barge was then thrown on the upper end; when a considerable strain was produced on the small lines attached to the mooring barge, they were slacked and the mattress allowed slowly to sink; this was repeated until the upper end reached the bottom, then a rock barge was swung over the mattress, being guided by lines held on the mooring barge and on the shore, and stone thrown on until it sank, care being taken to distribute the stone evenly.

The organization of the mattress party is as follows: one sub-overseer in charge, three master-laborers having charge of the three divisions of work, viz., at each end and in the middle of the mattress barge. Each gang consists of one patcher, one mauler, four weavers, five platform men, and three brush men; fourteen in all.

The brush men stand on the barge of brush which is lashed alongside of and below the mattress barge, and pass the brush to the platform men, who place it in position on top of the ways, then the weavers push it down into place, where it is firmly driven by the mauler. The patcher repairs any openings left in the mattress after weaving. Five wire men are employed on the mattress to put on binders and cross poles; one water carrier is employed. The total force, including everybody, being 52 men.

UPPER BANK REVETMENT.

This was constructed as follows: After the bank was graded to the proper slope, strong stakes were firmly driven in the ground, about 8 feet apart longitudinally and from 4 to 8 feet apart transversely to the bank. A No. 8 wire was then placed around the stakes longitudinally, their distance apart being 8 feet. Around this wire, at each stake, a No. 12 wire was placed and twisted around the stakes so that the ends could be had after brush was placed in position; this was to be used to tie the top and bottom wires together, thus holding the brush in place.

A layer of brush was now placed on the bank transversely, the butts up the bank and the tops overlapping the "deep-water mattress." On top of this a longitudinal layer was placed, and over all a No. 8 wire was stretched transversely, at every 8 feet; this was tied to the "deep-water mattress" and also to the bottom wire at each point of intersection. The whole was then well covered with stone. Whenever the "deep-water mattress" could not be joined to the upper bank revetment a foot-mattress was built to cover the space; this was constructed on a small screen barge, and was similar to the large mattress already described.

GRADING.

In order to revet the bank above the low-water line it was necessary to grade it to a suitable slope for holding the brush and stone. During the first part of the work, from December 21, 1882, to January 31, 1883, I used for this purpose hydraulic grader No. 2 of the Mississippi River Commission. This was loaned us by Capt. J. G. D. Knight, of Plum Point, and was returned to him shortly after the high water closed our work. Before again resuming work, August 6, 1883, we obtained a small pump boat from Capt. W. L. Marshall, of Vicksburg, Miss., and with the latter, work is now being done. Both will be described.

Hydraulic grader No. 2 consists of a duplex compound condensing plunger pump built by the Dean Pump Company of Holyoke, Mass. The dimensions are as follows: Diamoter of low-pressure cylinder, 36 inches; of high-pressure cylinders, 18 inches; diameter of plungers, 16 inches; length of stroke, 24 inches. The stroke is adjustable and in our practice was kept at about 23 inches. The piston speed averaged 61½ feet per minute, giving a theoretical discharge of 1,280 gallons of water per minute. This pump, together with three steel boilers of 40 horse-power each, was placed on a barge 130 by 30 by 6 feet, which contains sleeping quarters for 30 men. Attached to the delivery pipes of the pump is a boom 65 feet long, made of lap-welded wrought-iron tubes, joined with cast-iron connections, and having openings at various points to which hose can be attached. This boom, with a double stage, overhangs one end of the barge, and can be raised or lowered by a hoisting engine on deck. When in position for work the boat was held nearly at right angles to the bank, with the stage resting on the bank. The grader had not been run before we received it, and, like most new machinery of large size, some time was lost in limbering it up so as to work smoothly. Delay was also caused by some imperfections in the machinery, and its erection, resulting in the breaking of a guide-arm to slide-valve rod, the piston rod, and afterwards tappet arm of condensing pump; in the settling of the foundations of large pumps, necessitating the building under them of two additional bulk-heads; and in the small drift getting under the pump valves, thus destroying the suction. The latter was the principal cause of lost time, but the trouble was finally remedied by placing very fine screens over the ends of suction pipes.

The organization of the party for this grader was as follows: 1 assistant engineer in charge, 2 steam engineers, 2 firemen, 1 foreman, 3 nozzlemen, 3 deck-hands, 1 cook, 1 cabin boy; fourteen men in all.

Owing to the wet and dirty work, the foreman and nozzlemen were provided with waterproof suits complete, including caps, boots, and gloves.

The nozzle was supported upon a stand consisting of a piece of gas-pipe firmly driven into the ground, and well braced. To it was attached a piece of round iron, about one foot long, which passed into the pipe. This formed a universal swivel, the whole arrangement being light and quickly removable. A long lever, clamped to the nozzle, rendered its direction easy, so that a large stream was manipulated with about the same facility as a small one.

In working, the nozzle was held as near to the bank as practicable, and the stream directed against it at angles varying from 45° to nearly 90°. The top part of the bank was cut first, so as to allow the water to always flow along the face of the cut. After a short experience the nozzlemen had no trouble in holding the face. The material of the bank was hard blue clay and buckshot, interspersed with layers of softer material and sand, causing the banks to cave in steps.

Three sizes of nozzles 2, 1¾, and 1½ inch diameters were used, and two sizes of hose, viz, 4 and 2½ inches diameters.

After repeated trials it was found to be best practice, in the hard material worked, to use large nozzles, large hose, and but one stream. The water pressure at pump was held at from 135 to 140 pounds per inch. I think better results could be obtained by using still larger nozzles, as 2¼ to 2½ inches diameter. Experience in softer materials and sand shows best results from smaller nozzles and two streams.

The grader now used consists of a Dayton cam piston pump of the following dimensions:

	Inches.
Diameter of steam cylinder	16½
Diameter of water cylinder	9
Length of stroke	18

Supplied by a boiler of dimensions as follows: 20 feet long, 42 inches diameter of shell, having two 14-inch flues. The whole is mounted on a barge 100 by 16 by 3½ feet. The suction pipe is 6 inches in diameter, and the discharge is through from 100 to 150 feet of 3-inch six-ply test hose, with nozzle of 1½ to 1¾ inch diameters, the larger nozzle giving at date the best results. The theoretical discharge is at date 396 gallons per minute, the speed being 80 single strokes.

The party operating this grader is as follows: One steam engineer, one foreman, one fireman, three nozzlemen, and one deck-hand; seven in all.

During the month of September, 1883, I was obliged to keep water pressure down on account of the inferior quality of the hose; since then, with new 6-ply test hose, I have had on the pump a pressure of 240 pounds to the inch.

With grader No. 2 the slope cut was 3 to 1 from the water edge to the top of the bank. As the working capacity of the small grader was so much less, I have been obliged to grade to a greater slope, viz, 2 to 1 and 2½ to 1, being governed by nature of material, quantity to be removed, &c., and also to leave a vertical face, varying with the material, of from 6 to 12 feet. Under the head of "work done" will be found tables of results obtained with both graders.

WORK DONE TO NOVEMBER 1, 1883.

Preparations for commencing the work were made on December 6, 1882, by erecting quarters for the accommodation of 100 laborers, upon the bank near the upper end of the work, and by employing a small force to clear the bank of timber and brush. The entire length of the bend, a distance of over two miles, was cleared to an average width of 75 feet. Many large trees had fallen over the bank into the water, thus forming obstructions to the placing of mattresses. Your attention being called to this, you obtained the United States snag-boat H. G. Wright to remove them. Between December 7 and 14, 1882, she cleared about ½ mile of the bend.

On December 8, the steamer Emma Etheridge delivered the following plant: Hydraulic grader No. 2, two mattress boats, one machine-shop boat, one screen-boat, and one barge of coal.

Preparations were at once made to start the grading, which was begun on December 21, at which date, the quarters being finished, I commenced subsisting the men. Owing to the non-arrival of barges and quarter-boats for the brush party, the work of building mattresses was not begun until January 16, 1883, at which date Assistant Engineer Joseph Burney, who had charge of the work of protecting Memphis Harbor, commenced supplying me with brush. I obtained poles from bank clearing, and others by sending a party several miles up the river, they returning to the works at night.

From December 29, 1882, to January 15, 1883, the United States snag-boat Jno. R. Meigs was employed to tow willows, &c., to the works. At the latter date the chartered tow-boat H. M. Graham arrived and took the place of the Meigs.

MATTRESS CONSTRUCTION.

The construction of "deep-water mattress" was begun at Mound City ferry-boat landing on January 16, 1883, and continued until February 10; during which time 1,127 lineal feet of mattress, 140 feet wide, was constructed and sunk; 194 by 25 feet of foot-mattress and 194 by 16 feet of shore-protection were also completed.

The mattresses sunk were four in number and from 256 to 298 feet long; it being considered advisable to make short mattresses, on account of the rapidly-rising water and the great amount of drift running, much of which lodged against the mooring barge and caused a very heavy strain on the lines attached to it and to the mattress. The intention was to lap the mattresses by about 15 feet; but when sunk, owing to the drift pressure, gaps of this distance were found in two places instead of laps. There was used in the construction of the above 840.5 cords of brush, 105 cords of poles, 2,534 pounds of wire, 80 pounds of rope, 1,950 pounds of wrought spikes, 200 pounds nails, 585 cubic yards of stone, and 4,300 gunny-sacks. The latter were used to sink mattress No. 3, which was 298 by 140 feet in size; each sack was filled with about 120 pounds of buckshot clay, the total weight being equivalent to the weight of 214 cubic yards of stone. They cost when filled and loaded on barges about 9 cents each.

The depth of water in which mattresses were sunk was from 40 to 70 feet.

During the first ten days in February, 1883, the work was much retarded by bad weather. The water having risen from 7.50 feet on the Memphis gauge on January 16, to 23.30 feet on February 10, work was suspended on the latter date, the water being then on a level with the bank upon which quarters were located, and necessitating their removal.

The grading of the bank was begun December 21, 1882, and continued until January 31, 1883, when work was suspended on account of high water. During this time there was graded 1,793 linear feet of bank; 42,087 cubic yards of earth removed, at a cost of 94 cents per linear foot, or 4.03 cents per cubic yard. Table I, annexed to this report, will show in detail the work done.

On February 28, the tow-boat H. M. Graham was taken to Cairo.

From February 10 to August 6, 1883, no construction work was done, the water being too high. During this time a small force of mechanics were employed in getting barges, quarter-boats, &c., in readiness for this season's work.

On July 15, I received your verbal orders to prepare to resume work. The tow-boat Graham arrived on the 17th and was put in commission on the 20th.

A quarter-boat for brush party was at once fitted up and turned over to Joseph

Burney, United States Assistant Engineer. This party began work July 26, on Dean's Island, about 25 miles above. I received from them the first barge of brush on August 2, and began the construction of mattresses on August 6. After constructing 493 linear feet of mattress I deemed it expedient to sink it, as considerable drift had accumulated above the mooring barge, and much of it was getting under the mattress. Subsequently lengths of mattresses were increased to 900 and 1,000 feet. No trouble being met in sinking mattresses of this length, it was decided (September 29) to construct continuous mattresses. The mattress now being built is 2,150 long, 1,580 feet of which has been sunk. No trouble whatever has been met in sinking part of the mattress and keeping part afloat, nor do I apprehend any except from drift, in which case mattresses will have to be broken off and sunk when the drift causes excessive strain.

One willow party being insufficient to supply us, quarters for 70 men were erected on a barge, and a second party sent out on September 17. The water being too low for the tow-boat, both parties were withdrawn from Old River, west of Centennial Island, on September 24, and placed in the main river, where brush was scarce, and at a great distance from the river.

By October 15 the river rose sufficiently to permit entrance to Old River, and both brush parties were moved there.

Being short of brush, I organized a third party, and placed them on "Old Hen Island," just opposite the work. They are supplying at date 60 cords per day, our total requirements being about 200 cords per day.

Owing to short supply of brush, no shore work was done until October 2, although a considerable portion of the bank had been staked out and wired ready to have the brush placed in position.

On August 17 the snag-boat John R. Meigs began work in clearing the bend of snags. She finished on October 11, having removed five hundred and forty-one snags and ten rack heaps. Two men were lost by falling overboard.

On September 24 a small flat, loaded with 600 bushels of coal, was struck by a large drift log and sunk.

The following tables will show you the work done in detail:

TABLE No. 1.—HYDRAULIC GRADER No. 2.

Ten days ending—	Linear feet.	Cubic yards.	Average area of cross-section.	Time worked.	Yards cut per hour.	Average pressure.		Strokes per minute.	Coal.	Cost per cubic yard.	Cost per linear foot.	Composition of material.		
						Steam.	Water.					Buckshot.	Clay.	Sand.
1882.			Sq. ft	Hrs		Lbs. pr. sq. in.			Bush.	Cts.	Dols.	Pr. ct.	Pr. ct.	Pr. ct.
Dec. 31	175	4,620	700	51	90.6	95	135	32	600	8.8	2.21	45	55	....
1883.														
Jan. 10	385	7,022	475	42	167.2	95	135	32	625	5.5	1.01	45	45	10
Jan. 20	595	16,034	730	77	208.0	98	140	33	995	2.8	0.75	40	30	30
Jan. 31	638	14,411	640	85½	170.0	95	140	32	900	3.1	0.708	65	30	05
Total...	1,793	42,087	.....	255½	....	....	....	...	3,120	....	.....	....	....	....
Av'rage	......	....	.....	....	165.0	....	137.5	....	......	0.0403	0.94	49	40	11

TABLE No. 2.—DAYTON CAM PUMP.

1883.														
Sept. 10	1,205	4,150	.....	80	52	90	95	64	150	3.5	0.120	40	25	85
Sept. 20	900	5,245	.....	90	58	90	95	64	175	2.9	0.170	16	30	54
Sept. 30	655	4,105	.....	80	51	80	120	64	209	3.5	0.322	50	30	20
Oct. 10	1,475	4,290	.....	82½	52	80	125	72	175	3.5	0.105	72	13	15
Oct. 20	1,075	4,195	.....	82½	51	80	130	72	144	3.5	0.140	30	45	25
Oct. 31	570	3,170	.....	60	53	80	135	82	108	4.0	0.244	No record.		
Total...	5,880	25,155	.....	475	....	....	....	....	971	....	.....	....	....	....
Av'rage	......	....	.....	....	53	....	....	....	......	3.5	0.150	....	....	....

RÉSUMÉ OF GRADER WORK.

Linear feet of bank graded	7,673
Cubic yards of earth removed	67,242
Cost per linear foot	$0.334
Cost per cubic yard	0.038

Mattress work done is as follows:

Mattress No. 1, sunk January 23, 1883	298′×140′	
Mattress No. 2, sunk January 27, 1883	275′×140′	
Mattress No. 3, sunk February 3, 1883	298′×140′	
Mattress No. 4, sunk February 10, 1883	256′×140′	
		1127′×140′
Mattress No. 5, sunk August 11, 1883	493′×140′	
Mattress No. 6, sunk August 23, 1883	850′×140′	
Mattress No. 7, sunk September 4, 1883	952′×140′	
Mattress No. 8, sunk September 15, 1883	925′×140′	
Mattress No. 9, sunk September 28, 1883	1032′×140′	
Mattress No. 10, sunk October 23, 1883	1580′×140′	
Mattress No. 10, afloat	570′×140′	
		6402′×140′
Total amount of deep mattress made		7529′×140′
Total amount of deep mattress sunk		6959′×140′

In addition to this there was made and sunk a mattress 100 by 300 feet to cover a cave in bank between mattresses Nos. 3 and 4, due to their not lapping.

At date (November 1) 6,700 linear feet of bank is covered by "deep-water mattresses," and 4,100 linear feet by "upper-bank protection." The total revetment is 120,918 square yards.

In preparing for work, the following (mostly heavy) timber was cleared from the bank:

	Acres.
From December, 1882, to February, 1883	16
From August, 1883, to November 1, 1883	9
Total clearing	25

Table showing material used in construction.

Material.	Deep-water mattress.		Upper bank protection.	Total.
	January and February, 1883.	August to November, 1883.		
Brush ... cords..	840.5	4,885.0	938.0	6,663.5
Poles ... do ..	105.0	310.0	....	415.0
Wire ... pounds..	2,535.0	18,072.0	4,176.0	24,783.0
Spikes ... kegs of 150 pounds..	13.0	44.0	....	57.0
Nails ... kegs of 100 pounds..	2.0	11.0	....	13.0
Stone ... cubic yards..	585.0	3,703.0	454.0	4,739.0

I have on hand the following plant, viz:
One quarter-boat, 130 by 25 feet, capacity 180 men.
One quarter-boat, 100 by 20 feet (double-decked), capacity 120 men.
One quarter-boat, 90 by 20 feet, capacity 60 men.
One quarter-boat, 82 by 18 feet, capacity 80 men.
One quarter-boat, 80 by 18 feet, capacity 24 men.
One quarter-boat, 60 by 16 feet, capacity 30 men.
Five small flats used in construction.
Four screen-barges, 100 by 25 feet.
Two mattress-ways, 160 by 30 feet.
One hydraulic grader-boat, 100 by 16 feet.
One machine shop, 130 by 24 feet.
One decked barge, 130 by 24 feet.
Twenty-three decked barges, 100 by 25 feet.
One decked barge, 100 by 18 feet.
Thirty-nine skiffs.

Very respectfully, your obedient servant,

W. M. REES,
United States Assistant Engineer.

Maj. A. M. MILLER,
Corps of Engineers, U. S. A.

K 3.

REPORT OF F. S. BURROWES, ASSISTANT ENGINEER, UPON A SURVEY OF THE MISSISSIPPI RIVER IN THE VICINITY OF MEMPHIS.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., March 12, 1883.

CAPTAIN: I have the honor to submit the following report upon the survey of the Mississippi River, in the vicinity of Memphis, made under your instructions during the past year.

The survey was begun May 5, 1882, under the direction of your predecessor, Maj. W. H. H. Benyaurd, Corps of Engineers, United States Army, and at that time was intended to include only that portion of the river from Mound City Landing to the head of President's Island, a distance of 7 miles. Ten days after field work was discontinued, for the time being, on account of high water, and, owing to the long continuance of the same, was not recommenced until by your orders, on August 1. The work on this portion was then pushed slowly forward; the party consisting of myself and three men only, as on account of a lack of funds available at that time economy was necessary.

In the latter part of August, as you were informed that an allotment had been made for the completion of the survey, the party was increased by the addition of a transitman and several skiffmen, and the work further facilitated by the use of the steam-launch Daphne.

About the time of the completion of the survey, as originally projected, I received your orders to continue it up the river to the foot of Island No. 40, an additional distance of 7½ miles, and soon afterwards received your further instructions to extend it down the river to Scanlan's Landing, a distance of 15¾ miles, making a total length of survey along the main channel of 30 miles, and reaching from the foot of Island No. 40, 11½ miles above the foot of Jefferson street, Memphis, to Scanlan's Landing, 18½ miles below the same point. This constitutes the survey as finally completed, and I will therefore consider it as a whole.

As there had been a very complete survey of almost the entire portion of this reach of river made in 1877-'78, under the direction of Lieut. Col. C. B. Comstock, Corps of Engineers, United States Army, the primary object of the present resurvey was to ascertain the changes in the bed and banks since that time; that is, the location and amount of the erosion of the banks, the accretion or formation of bars, and the scour or fill of the bed of the stream.

METHOD OF MAKING SURVEY.

A complete triangulation of the reach having been made, both under the direction of General Comstock and by the Coast and Geodetic Survey (the notes of which were furnished this office), and as most of their points were still intact it was not deemed necessary to make an entirely new trigonometrical survey. Both for economy of time and in order to make a more exact comparison with the previous survey, those old points which were found to be in good order were used in the new survey, and the ones which had been destroyed and were necessary to insure the accuracy of the work were replaced.

The bank and bar lines between the triangulation stations were determined by stadia measurements, as were also the sounding stations. Soundings were located by intersections from two transits on shore, usually placed on the bar or convex side of the river, so as to give the best angles of intersection.

Several methods of making soundings were tried and the one most generally used was adopted as giving the greatest number in a given time. A skiff, with three oarsmen, a leadsman, and a recorder, was rowed rapidly back and forward across the stream and the lead cast every half-minute. Every second sounding being located by the transitmen sighting on a flag raised and quickly lowered by the recorder at the instant of sounding. In order to keep a check on the numbers the flag was quickly raised and lowered twice at every fifth sounding, and such double flag noted by both transitmen and recorder. On account of its too great draught the steam-launch was found to be of very little utility in the actual taking of soundings at a low stage of water. It was, however, used to a considerable extent in the immediate vicinity of Memphis, the soundings over this portion being taken in longitudinal lines. The lead was cast but once for each line and the launch and lead-line kept drifting together. Soundings were taken every fifteen seconds and every fourth sounding located. This method, without doubt, gives the most accurate results, but was abandoned on account of the great length of time consumed.

THE CHARTS.

The map of the river submitted herewith consists of four charts, made to a scale of 1:10,000, numbered from one to four, beginning at the foot of Island No. 40. As probably the best method of describing the reach surveyed, I will take up the charts in numerical order, and consider them separately.

Chart No. 1 extends from the foot of Island No. 40 to Mound City Landing, a distance along the channel line of 7½ miles. Of this portion of the river, only that part had been previously plotted by the "Comstock survey" between the head of Old Hen Island and Mound City Landing. Heavy caving is shown to have taken place on the head of Old Hen Island, and the bar below has kept moving down the river, following the rapid caving in of Hopefield Bend. Above Mound City Landing, the caving on the right bank since the "Comstock survey" is inconsiderable. Above the head of Old Hen Island, the previous survey was made under the direction of the Mississippi River Commission, in 1879-'80. As their maps, plotted to a large scale, have not been furnished this office, I have not been able to place their shore-lines on the new maps. Throughout the reach of river on this chart, the width between bank lines is excessive, varying from 3,000 to 6,000 feet; but, at the stage to which the chart is plotted, the widths of the water-way are as follows: 3,000 feet at foot of Island Forty, thence contracting to 2,000 feet in next three miles, and again widening to 5,000 feet at head of Old Hen Island.

The soundings and shore-lines on this chart are reduced and plotted to a stage of water which corresponds to a reading of 11.4 feet on the Memphis gauge.

Chart No. 2 extends from Mound City Landing to the head of President's Island, a distance along the channel line of 7 miles, and includes the river-front and harbor of Memphis.

The most noticeable change shown to have taken place on this portion of the river is the heavy caving above Hopefield, extending from Mound City Landing to Hopefield, and amounting to a maximum cutting of 1,200 feet, in the middle of the bend, since the survey of 1877-'78. Rapid caving is also taking place on the left bank above Wolf River. This caving, by comparison of more recent surveys, seems to be increasing in rapidity. Gradual caving is also shown to have taken place on the river-front of Memphis, above Jefferson street. This portion of the front has been partially revetted during the past four or five years, and the caving thereby stopped, or at least checked, as considerable caving of the top bank has taken place during the past year, which, although not showing largely on this map, is of considerable importance on account of the value of the property affected.

The water-way in front of Memphis and in a part of Hopefield Bend is contracted to a width of only 1,600 or 1,800 feet, at the stage of water to which the chart is plotted. This chart also shows the sweep of the bend opposite Memphis and the course of Four-mile Bayou, extending almost across it. The shortest distance through this bend is 13,600 feet.

The soundings and shore lines on this chart are reduced and plotted to a stage of water which corresponds to a reading of 11.4 feet on the Memphis gauge.

Chart No. 3 includes the whole of President's Island, and shows the main channel and chute on either side of it. The nearly equal division of the low-water discharge of the river at the head of the island has apparently been the cause of shoaling and contracting the low-water channel of the main river along its north and west sides.

Between the mouth of Four-mile Bayou and Lake's Landing, the width of the water-way, at the stage to which the chart is plotted, is only 1,300 feet. Below Lake's Landing it widens out, but becomes shoal, and by the formation of a middle bar, one mile above Rowley's Landing, the actual available channel is contracted to 600 feet, and maintains this width for 2,000 feet. The clear high-water width of the main river averages from 4,000 feet to 5,000 feet, exclusive of the chute between President's and Vice-President's Islands.

The principal caving shown to have taken place in this portion of the main river extends from the head of the Apperson plantation to Jones's Landing, where there has been an average cutting of from 400 feet to 500 feet, for a distance of 10,000 feet. Caving has also taken place immediately above Lake's Landing, averaging 200 feet in width by one-half mile in length, and from the mouth of Four-mile Bayou, upstream, there has been an average caving of 150 feet for a distance of a mile.

The chute to the east and south of President's Island has a very uniform width between bank lines, varying only from 2,000 to 2,200 feet. At low stages its width in the bend is contracted by a bar to 1,200 feet, and a middle bar, or reef, also obstructs the upper end of the chute, for a distance of about a mile. From the lack of necessary tools and appliances for making the examination I was not able to judge of the nature of the material of which this reef is composed; but the bottom of the whole upper portion of the chute, as indicated merely by the feel and effect upon the sounding-lead, seems to be of a hard, gravelly nature. From the foot of the bluff, at the head of the chute, a reef of ferruginous sand-rock juts into the stream, showing at a stage about 10 feet above low water; and this middle bar may possibly be of the same nature. In this connection, from the report of Assistant Engineer E. H. Wilson to the secretary of the Mississippi River Commission (June, 1881), I find the following information concerning the nature, depth, and probable location of this rock. At boring No. 1, located at the foot of the bluff, about three-fourths of a mile below the head of the chute, ferruginous sandstone stopped further progress at a depth of 107.4 feet below the top of the bluff, which, according to his diagram, would be about on a level with the low water of 1872.

In describing this boring Mr. Wilson says: "The sand rock which stopped the progress of the boring, it seems, is here of unusual extent, appearing above the water at low stages of the river some distance from the bank, which, washing away the overlying material, has been unable to remove the rock. * * * It seems possible that the submerged bar which extends from this point to the head of President's Island, may be an extension of this sandstone layer."

With the exception of the middle bar referred to, I did not find any shoal of a possible rocky formation in the stream, which would appear above the water at its lowest stage. At two points in the chute, where some disturbing elements on the bottom (claimed by some to be rock reefs) have caused large boils on the surface, there was found not less than 19 feet of water at the stage sounded—6.5 feet on the Memphis gauge.

The supposition as to the rocky nature of the middle bar may, very likely, be correct; but a thorough examination is necessary, in order to establish it as something more than a mere hypothesis.

The distance through the chute is 1½ miles shorter than by way of the main river at low stages of water; the length of the main channel being 7¾ miles, and by way of the chute, 6¼ miles.

The principal caving shown to have taken place in the chute is at the head of President's Island, where there has been an average cutting of from 200 feet to 500 feet for a distance of a mile; and also on the foot of the island averaging 300 feet in width by one-half mile in length. Slighter caving, varying from 50 feet to 100 feet in width by two miles in length, has also taken place on the Tennessee shore below Nonconnah Creek.

The soundings and shore lines on this chart are reduced and plotted to a stage of water which corresponds to a reading of 6.5 feet on the Memphis gauge.

Chart No. 4 extends from the foot of President's Island to Scanlan's Landing, a distance along the channel of 8 miles.

The width of the river between banks throughout almost the whole of this reach is very excessive, being from 5,000 to 6,000 feet.

From Reeves' Landing to Harris' Landing, where the width from bank to bank is 6,000 feet, a middle bar has formed, which, at low water, divides the river into two channels, both of which are navigable for small boats of light draught, the one on the right, however, being the main channel and the only one through which large boats can pass with any degree of safety.

The bars at Hampton and Scanlan's Landing have been found to be greatly increased in size and are gradually moving down stream. The width of water-way of the main channel, as contracted by the bars at the stage of water at which the survey and map were made, is 2,600 feet at Ensley's plantation, 4,000 feet at Hampton Landing, 1,700 feet at Reeves' Landing, keeping about this width to Harris' Landing, then widening to 5,000 feet on the crossing below, but soon contracting again to 2,500 feet and keeping about this width to near Scanlan's Landing.

The principal caving found on this reach is at the following points: Between Reeves' and Harris' Landing where, for a distance of 4,000 feet, there has been an average cutting of 300 feet; below Fleece's plantation, where there has been a cutting of 200 feet to 400 feet, a distance of 3,600 feet; and on the head of the old Cow Islands, where the caving has been from 200 feet to 600 feet in width, by a mile in length.

Slight and inconsiderable caving has also taken place on the lower end of Ensley's plantation, between Horn Lake and Collins' Landings, and below Scanlan's Landing.

The soundings and shore lines on this chart are reduced and plotted to a stage of water which corresponds to a reading of 6.5 feet on the Memphis gauge.

SLOPE OF THE RIVER.

While the party was at Hampton Landing, a daily gauge record was kept at that point, the zero of the gauge being connected with that at Memphis, by means of the levels of the "Comstock" survey. In the following table are given the daily gauge readings at both points from November 30 to December 13, the zero of the Hampton gauge being reduced to the same level as that at Memphis. The daily differences in level and slope per mile are also given. Taking from this table 0.5308 foot, the average slope per mile, and multiplying by 7¾ miles (the distance around President's

Island by way of the main channel), we get 3.8483 feet as the difference in level between the head and foot of the island; and, dividing this by 6½ miles, the distance through the chute, gives 0.5920 feet as the average slope per mile through the chute.

Table of slopes.

Date.	Gauge readings.		Distance.	Difference in level.	Slope per mile.
	Memphis.	Hampton Landing.			
1882.	*Feet.*	*Feet.*	*Miles.*	*Feet.*	*Feet.*
November 30	6.35	—0.24	12½	6.59	0.5272
December 1	6.30	—0.24	12½	6.54	0.5232
December 2	6.25	—0.26	12½	6.51	0.5208
December 3	6.30	—0.31	12½	6.61	0.5288
December 4	6.30	—0.31	12½	6.61	0.5288
December 5	6.40	—0.26	12½	6.66	0.5328
December 6	6.40	—0.26	12½	6.66	0.5328
December 7	6.45	—0.31	12½	6.76	0.5408
December 8	6.60	—0.26	12½	6.86	0.5488
December 9	6.80	+0.09	12½	6.71	0.5368
December 10	6.60	+0.09	12½	6.51	0.5208
December 11	6.50	—0.11	12½	6.61	0.5288
December 12	6.25	—0.31	12½	6.56	0.5248
December 13	6.00	—0.71	12½	6.71	0.5368

DISCHARGE OBSERVATIONS.

In order to ascertain the relative amounts of water passing on either side of President's Island, discharge observations were taken in both the chute and main river, a short distance below the head of the island, on the following days, December 29 and 31, 1882, January 2 and February 20 and 21, 1883. The results of these observations are given in the following table:

Table of discharges.

Date.	Memphis gauge reading.	Main channel.				Chute.				Total discharge per second.
		Area of section.	Discharge per second.	Mean velocity.		Area of section.	Discharge per second.	Mean velocity.		
				Per second.	Per hour.			Per second.	Per hour.	
1882.	*Feet.*	*Sq. feet.*	*Cubic feet.*	*Feet.*	*Miles.*	*Sq. feet.*	*Cubic feet.*	*Feet.*	*Miles.*	*Cubic feet.*
Dec. 29	8.35	29,435	113,295	3.8490	2.6243	39,264	183,181	4.6654	3.1810	296,476
Dec. 31	9.80	32,817	123,965	3.7753	2.5741	42,362	199,497	4.7093	3.2109	322,462
1883.										
Jan. 2	10.40	34,035	139,071	4.0861	2.7860	43,394	206,573	4.7604	3.2457	345,644
Feb. 20	32.80	141,407	618,268	4.3723	2.9811	104,519	548,758	5.2503	3.5798	1,167,026
Feb. 21	33.30	143,904	631,346	4.3873	2.9913	105,733	562,715	5.3220	3.6286	1,194,061

From the above table it will be seen that on December 29 and 31, 1882, and January 2, 1883, when the water was at a medium low stage, the discharge through the chute was about sixty per cent. greater than through the main river, but on February 20 and 21, when the river was bank full, the discharge through the main channel was about 10 per cent. greater than through the chute.

These observations were made with floats, running a distance of 200 feet.

The floats were of the same pattern as those used by this office in making discharge observations in 1879.

Very respectfully, your obedient servant,

F. S. BURROWES,
Assistant Engineer.

Capt. A. M. MILLER,
Corps of Engineers, U. S. A., Memphis, Tenn.

K 4.

REPORT OF F. A. FISHER, ASSISTANT ENGINEER, UPON A SURVEY OF THE HELENA REACH.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., May 31, 1883.

CAPTAIN: I have the honor to present to you the following report of the survey of the Helena Reach, Mississippi River, you intrusted to my charge during the season of 1882-'83:

In accordance with your letter of instructions, dated October 16, 1882, I at once organized a party and procured the necessary outfit. The party consisted of one assistant engineer, in charge; two sub-assistants; four rodmen; one leadsman; seven oarsmen, and one cook; the quarter-boat being just large enough to accommodate that number of men. I left Memphis October 22, 1882, allowing the boat to drift and piloting it with my two well-manned skiffs to Commerce Landing, arriving October 24.

The instruments furnished me were: Transit No. 4840 (Heller and Brightly); transit No. 8 (Gurley); level No. 4918 (Heller and Brightly).

The survey comprised a tertiary triangulation, shore line of both banks, of bars, tow-heads, islands, and topography of same; soundings and necessary level connections between United States bench-marks and gauges; and, also, according to further instructions, dated November 25, 1882, location of levees along the river, when it did not extend the survey too far, and the ascertaining the level of high water of 1882.

Secondary triangulation station "Peters," being the only one near the beginning of my work which could be found, observations for azimuth were made near Commerce Landing, and the triangulation carried from a carefully measured base-line, 4,092 feet in length, connecting this point with triangulation station "Peters," to a check-base at the head of Bordeaux Chute, where observations for azimuth were also made, as a check on previous determination.

Near O. K. Landing, Miss., the first complete connection with secondary triangulation through line triangulation station O. K—triangulation station Waddell, azimuth 176° 04′ 37″.54, was made. My observed azimuth checked within one minute. The next connection was made at Helena, Ark., with line triangulation station Battery Hindman—triangulation station Court-house, and again at Friar's Point, through line triangulation station Ship—triangulation station Westover.

Gauges to determine river slope, were placed at such points along the river as seemed to indicate a change of inclination; and, elevation of their zeros was determined by levels from known elevation of United States bench-marks. A number of such United States bench-marks were connected by chain and transit with tertiary triangulation points.

Simultaneous readings of the gauges were taken at two points, usually for six hours in succession, and days selected for slope determination at a nearly stationary stage of the river. The result, with dates when observed and stage of river at Helena, are given in Table No. 1. The rate of caving of banks on the "reach," for the time between the surveys of 1878-'79 and 1882-'83, is given for the different sections in Table No. 2. Sand-bars have not been considered in this estimate.

The level of high water of 1882 is given in Table No. 3. The stage of water at Memphis, Tenn., and Helena, Ark., is given in Table No. 4. The amount of work done is given in Table No. 5.

TOPOGRAPHY.

On this "reach" many of the secondary stations have been washed away; in some instances plowed up, and in others buried under mud, and sand, some 2 or 3 feet deep. Tertiary points were substituted and placed in close proximity to each other, so as to avoid the cutting of heavy timber. Stadia lines were run between stations, and all points inland taken as far as stadia could be read. Elevations as given on the charts depend, in feet, on a plane which is 225 feet below high water of June, 1858. This high water corresponds to a reading on Memphis gauge of 34.16 feet.

SOUNDINGS.

In sounding, a lead weighing 17½ pounds was used. The original lead weighed 20 pounds, but I found it too heavy for satisfactory use, so I reduced its weight as given above. The lead-line measured 100 feet; the actual length of which was determined by a standard measure at all times before its use, and correction noted in its proper place in sounding-books.

Generally, lines were sounded at an interval of about 1,000 feet, but at less distance whenever the river bed appeared changeable. Two transits occupied such triangulation stations as would give the best determination of position of sounding-boat when the flag was raised.

On the charts, soundings are expressed in feet and are reduced to that stage of water which corresponds to a reading of 12.82 feet on the Helena gauge; being the mean for the 19 days on which soundings were taken. The elevation of this stage of water is 161.54 feet, or 55.61 feet below United States bench mark $\frac{22}{4}$. High water of 1882, at Helena, was 34.26 feet above the stage of water to which the charts are reduced.

The dates in the river bed indicate the days on which soundings were taken.

The readings of Memphis and Helena gauges on these days are given in Table No. 4. Helena gauge is read twice during the day, at 9.30 a. m. and 1.30 p. m. The mean of these two readings has been taken.

CAVING BANKS.

Table No. 2 gives a list of localities and the rate of caving. The rate is determined from a comparison of the present position of the shore-line with its position at former surveys. It will be observed that the caving at east side of Bordeaux Island is going on very rapidly, as much as 1,100 feet in one year; and as the whole distance across to Old River, above Walnut Bend Landing, is only 1,117 feet, the river will doubtless, at no distant date, break through and resume its original bed in Walnut Bend. I have added to this report a reduced plot of this interesting section of river. (Plate II.)

BARS AND TOW-HEADS.

The bar opposite Commerce Landing, between old and new river, has extended down the river about one-half of a mile, and is composed of a very fine and easily shifting sand, except on the northern portion, where a small belt of gravel predominates. At the southern end is some silt and mud. The opening at Linwood Point, into Council Bend, is closing rapidly. The bar immediately below, on Mississippi shore, is composed mainly of sand with some silt at extreme southern end. Clark's Tow-head is now merged into this bar and has lost its identity.

The bar opposite Mhoon's Landing, "Ashley Point," is, at its highest elevation, composed of sand. Along the bluff or main shore, gravel exists and varies in size from 0.5 inch down to coarse sand.

The bar at the head of Bordeaux Chute consists of a very fine sand; the southern and eastern end of it, where it joins on the main shore, is composed of mud.

The Walnut Bend bar has extended down stream three-fourths of a mile, with fine sand on its surface; below it, however, at a depth of one or two feet, it becomes coarser and is mixed with pebbles as much as 0.75 inch in size.

This bar will, in the near future, become, no doubt, an island, as the river above is forcing its way rapidly through to the old Walnut Bend Channel.

The large bar on Mississippi side above O. K. Landing, as well as two small bars detached from it, are composed of a coarser kind of sand than usually found; probably 30 per cent of it consists of quartz particles from 0.04 to 0.05 inch in size.

Fox and Ship islands are merged into this bar. At its eastern extremity, where it forms the shore of an inlet (formerly river), is a belt of mud which extends up as high as B. M. $\frac{16}{8}$. The large and smaller island bars, as well as shore bar opposite O. K. Landing, are composed of fine sand with mud surrounding them. The island immediately below O. K. Landing, in midstream, consists of coarser sand mixed with large-size pebbles, some as much as 1.5 inch in size.

The bars forming opposite Harbert's Landing are composed of fine sand. Shoo-Fly Bar, below Harbert's, is sand in its main body with some gravel at its northern end. This bar has assumed quite a different shape since 1878. From being egg-shaped, with greater axis lying across the stream, it has assumed a long, narrow shape running with the channel of the river. It has extended to 1¼ miles below its former southern end, holding meantime its head pretty well. The main channel of river crosses at this point from Mississippi shore to Arkansas side and passes close to north end of this bar. The channel between it and Mississippi shore has a tendency to fill. The bar opposite mouth of Saint Francis River, which includes at the present time Saint Francis Tow-head, is a fine quality of sand. The tow-head itself is composed of silt and covered with large-sized cottonwood; the former channel between tow-head and main Mississippi shore is filling.

The Prairie Point bar has assumed a very large dimension, closing the former existing channel between it and Arkansas shore almost entirely. The northern part of this bar is composed of a very fine, almost dust-like sand. At the eastern slope of this bar coarse sand with particles of from 0.25 to 0.5 inch occur. The southern part has a small stretch of silt and mud, mainly along water edge. Helena Tow-head is composed of fine sand, excepting at Helena end, and also along eastern edge, where some silt is found. It is covered with a heavy growth of willows and cottonwood.

The bar extending from below Glendale to Thompson's Landing is chiefly sand with some mud spots on lower part close to water. Some gravel is found near the upper portion of the bar, the size of which varies from 0.1 to 0.3 inch in diameter.

Montezuma Bar consists of sand mainly. Some gravel is found, but not in large quantities. As a rule, it has been observed that the higher parts of bars consisted of very fine sand, increasing gradually in size towards the water's edge. The general size of sand as it occurs is about from a dust-like form to 0.05 inch; that of gravel from 0.2 to 0.5 inch, with occasional pebbles of 1 inch in diameter.

The survey was completed to a half mile below Friar's Point, by January 27, 1883, at which date the tug Clarence arrived to tow quarter-boat back to Memphis, where we arrived January 31, at which date party was disbanded.

My thanks are due to Messrs. W. L. Killebrew and C. A. Dinsmore, who assisted me willingly and ably in the prosecution of this work.

Very respectfully, your obedient servant,

F. A. FISHER,
United States Assistant Engineer.

Capt. A. M. MILLER,
Corps of Engineers, U. S. A.

TABLE No. 1.—*River slope.*

Locality.	Date.	Distance between gauges.	Stage of river at Helena.	Rise or fall per hour.*	Slope per mile.	Remarks.
	1882.	*Miles.*	*Feet.*	*Feet.*	*Feet.*	
From lower end of bar near Campbell's Landing to Mhoon's Landing.	Nov. 13	3.44	11.62	0.00	0.568 **1.937**	Gauge 2 is in a cove on lower end of bar. Gauge 3 is in Old River, ½ mile above Mhoon's; no current.
From Mhoon's to head of Bordeaux Chute.	Dec. 5	4.78	12.10	0.00	0.427 **2.028**	Gauge at Bordeaux Chute in slight current, on east bank, head of bar.
From head of Bordeaux Chute to foot of same.	Dec. 20	3.78	8.55	−0.03	1.126 **4.222**	Gauge at lower end of sand bar, opposite Walnut Bend Landing, in still water.
From foot of Bordeaux Chute to small island below O. K. Landing.	Dec. 29	6.81	13.17	+0.11	0.367 **2.510**	Gauge in current on east side of bar.
	1883.					
From island below O. K. Landing to mouth of Saint Francis River.	Jan. 6	8.09	16.55	0.00	0.401 **3.256**	Gauge 700 feet in Saint Francis River, above mouth, in still back-water of Mississippi.
From mouth of Saint Francis River to foot of bar opposite Trotter's Landing.	Jan. 16	7.34	13.55	0.00	0.236 **3.198**	Gauge in still water on west side of bar.
From Trotter's Landing to Gauge No. 8, below Helena, on Arkansas shore.	Jan. 23	4.85	15.40	+0.02	0.560 **2.699**	Gauge in current on Arkansas shore, 2.75 miles below Helena, Ark.
From Gauge 8, below Helena, to foot of Montezuma Tow-head.	Jan. 24	5.45	16.95	+0.03	0.362 **1.962**	Gauge located in still water on Arkansas shore.
From foot of Montezuma Tow-head to Westover, opposite Friar's Point.	Jan. 27	2.29	20.50	+0.10	0.351 **0.793**	Gauge located in still water on Arkansas shore.
					22.605	Slope for entire distance.

*Rise +. Fall −.

NOTE.—Figures in heavy-faced type give sum of slope for whole respective distance. The mean reading of Helena gauge for the nine days on which slope was determined, is 14.27 feet.

Below is given a list of localities and the rate of caving. The rate is determined from a comparison of the present position of the shore-line with its position at former survey.

TABLE No. 2.—*Caving banks.*

Locality.	Rate of caving per year.	Total caving.	Material.	Remarks.
	Feet.	*Feet.*		*Since—*
Ashley Point, Ark	320	640	Sand	Dec., 1880
Mhoon's Landing, Miss	250	500	Sand and silt	Dec., 1880
Bordeaux Point Landing, Miss	400	800	Sand	Dec., 1880
Bordeaux Island (east side)	1,100	2,200	Clay and sand	Dec., 1880
Shore opposite Walnut Bend, Miss	400	800	Sand	Dec., 1880
Smith's Landing, Ark	540	1,080	....do	Jan., 1881
One and a half miles above Harbert's Landing	132½	530	Clay and sand	Nov., 1878
Opposite Shoo-Fly Bar, Ark	327½	1,310	Sand and silt	Dec., 1878
Mouth of Saint Francis River	75	300	Clay and sand	Dec., 1878
Below mouth of Saint Francis River	182½	730	....do	Dec., 1878
Trotter's Landing, Miss	312½	1,250	....do	Dec., 1878
Glendale, Miss	62½	250	... do	Dec., 1878
One and a half to 5 miles below Helena, Ark	250	1,000	Silt and sand	Dec., 1878
Delta, Miss	162½	650	....do	Jan., 1879
One and a half to 2½ miles below Friar's Point, Miss	140	280	... do	Feb., 1881

TABLE No. 3.—*Elevation of high-water marks of* 1882.

Locality.	Elevation.	Distance.	High-water slope per mile.	High-water slope for the distance.	Description of marks.
	Feet.	*Miles.*	*Feet.*	*Feet.*	
At Dr. Peters' store, opposite Commerce Landing.	209.43	......	......	......	This mark is defined by a nail driven in the side of the counter inside the store.
Mhoon's Landing, Miss	208.13	5	0.260	1.30	Mark on tree, close by B. M. [illegible].
Bordeaux Point Landing, Miss.	207.49	3	0.213	0.64	Mark on house of Henry Wilson.
Walnut Bend Landing, Ark	204.70	4	0.697	2.79	Two nails in door-post of store.
Austin, Miss	202.75	......	......	......	Height above bench mark on corner court-house square, measured by county surveyor.
O. K. Landing, Miss	202.60	7	0.300	2.10	Mark on store and post-office.
Mouth of Saint Francis River	200.63	8.75	0.225	1.97	Mark on large tree opposite post-office.
Helena, Ark	195.88	9	0.528	4.75	Mark on window-sill of brick house opposite elevator.
Westover, Ark., opposite Friar's Point.	188.71	12.5	0.575	7.17	Well-defined mark on storehouse at corner of levee.
Total	......	49.25	......	20.72	Entire high-water slope.

NOTE.—Elevations as given in this table depend in feet on a plane which is 225 feet below high water of June, 1858. This high water corresponds to a reading on Memphis gauge of 34.16 feet. High water of 1882 corresponds to a reading on Memphis gauge of 35.15 feet, and on Helena, Ark. guage of [illegible] feet.

TABLE No. 4.—*Water gauges.*

[Showing stage of water at United States gauge at Memphis, Tenn., and Helena, Ark.]

Date.	Mean elevation of water in vicinity where soundings were taken.	Gauge reading at Memphis at 8 a. m.	Gauge readings at Helena at 9.30 a. m. and 1.30 p. m.	Mean of Helena gauge.
1882.	*Feet.*	*Feet.*	*Feet.*	*Feet.*
Nov. 3	177.13	5.22	10.55 10.70	10.63
4	177.13	5.22	10.60 10.70	10.65
13	177.46	6.18	11.55 11.70	11.62
20	174.50	7.20	12.90 12.11	12.50
24	174.98	6.75	12.75 12.80	12.77
Dec. 5	174.43	6.40	12.10 12.10	12.10
9	174.43	6.80	12.20 12.30	12.25
11	174.48	6.50	12.50 12.60	12.55
15	167.80	5.25	11.10 11.00	11.05
20	166.78	3.75	9.00 8.11	8.55
21	165.74	3.50	8.75 8.80	8.77
29	168.02	8.20	13.05 13.30	13.17
1883.				
Jan. 5	162.08	10.00	17.10 17.10	17.10
6	162.08	9.70	17.00 16.11	16.55
15	162.08	7.50	13.20 13.30	13.25
16	162.08	7.50	13.50 13.60	13.55
17	160.90	7.55	13.65 13.80	13.72
23	163.15	10.25	15.80 16.00	15.90
24	165.22	11.00	16.80 17.10	16.95
Mean for nineteen days				12.82

TABLE No. 5.—*Showing amount of work done from Commerce Cut-Off to Friar's Point.*

Tertiary triangulation stations built	185
Azimuths observed	3
Bases chained	3
Theodolite pointings	4,996
Leads cast, number of	6,184
Water-gauges set	11
Hydrography in miles along river channel, old and new	59
Shore-line in miles	135
Sand bars surveyed, number of	41
River slopes determined, number of	9
Miles of levels run from United States bench-marks to connection with gauges	10.5

K 5.

ESTIMATE OF RICHARD KLEMM, ASSISTANT ENGINEER, FOR REBUILDING AND REPAIRING LEVEES, SAINT FRANCIS AND PART OF YAZOO FRONTS.

UNITED STATES ENGINEER OFFICE,
Memphis, Tenn., March 15, 1883.

CAPTAIN: I have the honor to submit to you herewith estimates of amounts of cubic yards to be filled, and also the number of acres to be cleared for the repairing and rebuilding of the old State levees along the "Saint Francis front" on the west bank of the Mississippi River and the "Yazoo front" on the east bank of the river.

The Saint Francis front in this district extends on the Arkansas side from Island No. 40 to the mouth of Saint Francis River, and the Yazoo front, as far as surveyed, from the Chickasaw Bluffs, below Memphis, to Friar's Point, on the Mississippi side.

In accordance with your orders, I have prepared two estimates—one to give the amount of cubic yards needed to fill the gaps and breaks in the old levees, and one to give the amount of cubic yards needed to raise all levees 1½ feet above high water of 1882. The slope for new levees is calculated at 3 to 1 on the river side and 2 to 1 on the land side. The crown of the levees equals the fill up to a fill of 8 feet; above 8-feet fill the crown will not exceed 8 feet. The muck-ditch is 4 feet wide on top, 2 feet wide at the bottom, and 3 feet deep. At such places where previously no levees had been built, the calculations were made to a height of 1½ feet above high water of 1882 for both estimates.

The estimates are compiled partly from actual surveys made by Mr. Gartland and myself, and partly are taken from the charts made under the direction of General Comstock in 1878. From a point below Commerce, in Tunica County, to the Coahoma County line, the amounts are taken from notes and profiles made by the county engineer of Tunica County, Mr. G. W. Owens, and from Coahoma County line to Friar's Point, in Coahoma County, from notes and profiles made by Levee Inspector William Hewson.

The high-water marks are partly from my own survey and partly from Assistant Engineer Hunter Stewart. In locating the new levees, I followed the line of the old levees as near as possible. At such places where the old levees had caved into the river, I laid the new levees far enough back to probably be safe for some time. I attach a sketch on tracing linen, showing the old levees, and also showing, in red ink, the proposed line of the new levees. The map shows that all the old levees were constructed to protect the farming interests only, and that the distances between the levees on either side of the river vary from 1 to 6 miles.

I find that the highest ground is always along the river bank, and that most of the surface drainage goes towards the inland; on the Arkansas side, to the Saint Francis River basin, and on the Mississippi side towards the Coldwater and Yazoo basins.

Totals.

Location.	To height of old levees.	To 1½ feet above high water, 1882.	Clearing.
	Cubic yards.	*Cubic yards.*	*Acres.*
Arkansas side	1,188,126	1,634,153	678
Mississippi side	663,732	842,032	243

* * * * * * *

Very respectfully, your obedient servant,

RICHARD KLEMM,
Assistant Engineer.

Capt. A. M. MILLER,
Corps of Engineers, U. S. A., Memphis, Tenn.

TABLE No. 1.—*Estimates for repairing and rebuilding the old State levees along the Mississippi River, on the Saint Francis front, in the State of Arkansas.*

From—	To—	Distance.	To height of old levee.	To 1½ feet above high water, 1882.	Muck-ditch.	Clearing.
		Miles.	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Acres.*
Redman's Point (Mound City Breaks.)	Mound City	5	53, 092	174, 691	6, 699	46
Mound City (Hopefield Breaks.)	Four-Mile Bayou	9	76, 357	211, 738	5, 520	65
Four-Mile Bayou (Apperson and Reeves' Landing Breaks.)	Scanlan's Landing	13	24, 773	178, 379	3, 732	......
Scanlan's Landing (Cow Island Bend Breaks.)	Cat Island Landing	7	29, 990	60, 921	5, 412	80
Cat Island Landing (Horseshoe Breaks.)	Blue's Point	13	148, 758	153, 268	6, 999	84
Blue's Point (Council Bend Break, No. 1.)	Head of Council Bend	5	203, 537	203, 537	6, 993	80
Head of Council Bend (Council Bend Break, No. 2.)	Dr. Peters'	6	183, 953	183, 953	5, 406	74
Dr. Peters' (Ashley Point Levee.)	Head of Walnut Bend	5	100, 385	100, 385	8, 949	27
Head of Walnut Bend (Walnut Bend Breaks.)	Fall's Place	8	160, 616	160, 616	5, 751	80
Fall's Place (Hardin Point Levee.)	Mouth of Saint Francis	7	140, 539	140, 539	10, 665	142
Total		78	1, 122, 000	1, 568, 027	66, 126	678

TABLE No. 2.—*Estimate for repairing and rebuilding the old State levees along the Mississippi River, on the Yazoo front, in the States of Tennessee and Mississippi.*

From—	To—	Distance.	To height of old levee.	To 1½ feet above high water, 1882.	Muck-ditch.	Clearing.
		Miles.	*Cu. yds.*	*Cu. yds.*	*Cu. yds.*	*Acres.*
South Horn Lake (Taken from General Comstock's survey.)	Abbey's Field	28	82, 272	82, 272	7, 620	24
Abbey's Field (Taken from G. W. Owens.)	Austin	20	295, 204	406, 683	5, 500	120
Austin (From G. W. Owens.)	Coahoma County Line.	17	223, 688	274, 761	4, 120	81
Coahoma County Line (From William Hewson.)	Friar's Point	14	44, 298	60, 046	1, 030	18
Total		79	645, 462	823, 762	18, 270	243

TABLE No. 3.—*High-water marks,* 1882.

ARKANSAS.

Location.	Station.	Elevation.	Remarks.
		Feet.	
Redman's Landing	0	229. 62	Taken by J. Gartland.
	156+75	228. 68	Do.
Mound City	246+75	227. 85	Do.
Lake's Landing	830	224. 31	Taken by H. Stewart.
Merrywether's	1030	222. 226	Do.
Harris Landing	1260	221. 050	Do.
Scanlan's Landing	1430	219. 771	Do.
Dr. Peters'	3050	209. 40	Taken by R. Klemm.
Walnut Bend	....	204. 67	Do.
Mo. Saint Francis	....	200. 63	Do.
Helena Water Gauge	....	195. 88	Do.

TABLE No. 3.—*High-water marks*, 1882—Continued.

TENNESSEE AND MISSISSIPPI.

Location.	Station.	Elevation.	Remarks.
Memphis Water Gauge		225.99	Taken by H. Stewart.
Ensley's Landing		221.758	Do.
Norfolk Landing	580	215.217	Do.
Bennett's Landing	1070	211.228	Do.
Commerce Landing	1360	209.443	Do.
Mhoon's Landing		208.149	
Bordeaux Point		206.798	
O. K. Landing		202.663	

APPENDIX L.

REPORT OF CAPTAIN W. L. MARSHALL, CORPS OF ENGINEERS, UPON OPERATIONS IN THE THIRD DISTRICT.

UNITED STATES ENGINEER OFFICE,
Vicksburg, Miss., November 26, 1883.

SIR: I have the honor to transmit herewith my reports of operations for the works in my charge in the Third District, Improvement of the Mississippi River, under the supervision of the Mississippi River Commission, for the eleven months ending November 1, 1883, as follows:

1. Report on Lake Providence Reach, with sub-reports of Assistant Engineers Arthur Hider and J. E. Turtle, with nine plates. (I to IX.)
2. Report on revetment at Delta Point, La., and dredging in Vicksburg Harbor, with sub-report of Assistant H. St. L. Coppée, and four plates. (X to XIII.)
3. Levees.—Tensas and Yazoo fronts, with sub-reports of Assistant Engineers H. D. Garden and George M. Helm, with wood-cut plates.
4. Survey of Choctaw Bend Reach, with sub-report of Assistant Engineer Wm. T. Blunt.

I am, sir, very respectfully,

W. L. MARSHALL,
Captain of Engineers.

First Lieut. SMITH S. LEACH,
Corps of Engineers, U. S. A.,
Secretary Mississippi River Commission.

LAKE PROVIDENCE REACH.

This reach extends from Carolina Landing, 517 miles below Cairo, to the foot of Island 95, a distance of 35 miles. Work was begun under the appropriation of March 3, 1881, in February, 1882, and, with a short intermission in July and August, 1882, has been prosecuted continuously since that time.

The characteristics of the reach are sharp bends and very deep water and rapidly caving banks at head and foot of the reach; eight crossings from bank to bank, on some of which but 4½ feet of water was found at low water in years prior to the inception of the work; a stretch of 7 miles of straight river, from Island 93 to foot of Stack Island, and an excessively wide river at Skipwith, Island 93, head of Stack Island, and below Lake Providence. In the latter bend the width of river at high water reaches 9,600 feet where the channel is very much obstructed by shifting sand-bars of great extent.

The project for its improvement comprises the reveting and fixing permanently the bend at the head of the reach, the revetment of caving banks opposite and above works of contraction, and a general contraction of the width of the river to approximately 3,000 feet.

As a part of the contraction work proper, the closing of the following chutes is necessary.

(1) Skipwith Chute, about 1,200 to 2,000 feet in width at high water; (2) chute of Island 93, 900 feet in width; (3) Baleshed Chute, to crest of bar, 1,200 to 1,600 feet in width; (4) Stack Island Chute, 850 feet wide; (5) Elton Chute, to new shore-line on crest of bar, about 800 feet in width.

At the date of the last annual report, works had been inaugurated for the closure of Skipwith, Island 93, Baleshed, and Stack Island Chutes, and also the revetment work at the head of Island 93.

During the past year work has been directed towards the completion of these works, which have been greatly extended, and to the inauguration of the revetment work at Pilcher's Point, and contraction works at Elton or Hopewell Bar.

1.—REVETMENT AT PILCHER'S POINT.

The bends known as the Carolina, and Louisiana or Bunchs Bend, at the head of the reach, exhibit more rapid caving of the banks than any part of the reach, and the influence of the changes produced in the direction of currents below is plainly seen and felt. The entire length of caving bank in the two concave bends approximates seven miles. In the Louisiana Bend at Pilcher's Point, since December, 1881, the caving has been such that the Mississippi low-water shore-line now occupies in places the position of the Louisiana shore-line then, or the river has caved its entire low-water width during two high-water seasons, or about 1,500 feet. The water is excessively deep, reaching to 100 feet in depth at low water. The effect of this caving has been to throw the currents against the Mississippi shore above the contraction works at Skipwith, to partially undermine and destroy these works at the head of the chute, and to endanger the works located in Skipwith Chute itself.

In May, 1883, a party was organized under Assistant Engineer Willard, who was afterwards relieved by Assistant Turtle; the wooded banks cleared, and preparations made for beginning the mattressing of the banks there. After the decline in the river in August, mattress-work was started, but during the sickly season no progress could be made, as labor was too scarce to supply the works already in progress and incomplete. Since October 1, the party has been increased, a snag-boat secured from Major Miller to remove the snags from the bank to be mattressed, and about one-half mile of mattress work made, 1,228 linear feet of which has been sunk. This work, however, since it cannot be completed or made secure, on account of lack of funds, must now be abandoned.

2.—FROM DUNCANSBY TO STACK ISLAND.

This division of the work has been, during the year, under the local management of Assistant Engineer Arthur Hider, who submits a detailed report of operations, with maps and sketches appended hereto.

3.—DUNCANSBY SYSTEM.

This system embraces the first work of contraction on the reach. The river is here divided by two tow-heads, or dry sand-bars, into two channels, the deeper of which is on the Louisiana shore. The object of the silting works built here is to close the chute on the Mississippi side of the tow-heads; and at the head of the tow-head and in the upper chute five cross-dikes, the upper three of which were provided with foot-mats and screens, the two lower with screens only, have been built.

The longitudinal dike between the tow-heads was driven at high water and was consequently a high dike. The works in the chute and at head reached only to the 17-foot stage of water.

Upon the rise in February the water was thrown against the head of this system by the caving bend at Pilcher's Point, and parts of the upper dikes were washed out, but a very marked and decided fill occurred behind the remnants of the cross-dikes and longitudinal dike, between the tow-heads, the former of these, before being broken, having evidently offered sufficient resistance to determine the channel to the west of the tow-heads as desired. Along the longitudinal dike sand was piled up to the top of the piling in a very short while, and a rapid cutting away of the head of the upper tow-head, resulting from the river crossing above it, set in.

To prevent a threatened water-way at low water through the Skipwith Chute, and to hold the head of the tow-head, pile-driving was resumed at the head of the island and in the chute April 4, 1883. Cross-dikes were driven on Ranges 37, 38, and 39, as far as the stage of water would admit, and a screened dike 400 feet long driven across the head of the tow-head for the purpose of attempting to shield it against the current which set directly against it. At this time the water stood so high that brush for revetment could not be had. A small quantity of brush remained on hand, and this was used in constructing a mat 130 feet wide in rear of dike 37, to prevent a channel-way cutting through the chute.

Later in the season the head and upper flanks of the tow-head were mattressed, but the second rise went over the top of the island and washed it in two behind the mattress, which remains as an obstruction in the channel. The dikes on Ranges 37, 38, 39 have since been completed, except narrow channels for communication through them, and a heavy dike begun on Range 36. The details of these dikes are shown on the accompanying maps.

The works at Upper Duncansby have now, through the changes at Pilcher's Point, become too far advanced, and that system is seriously threatened with destruction. A line further retired must be defined by the river itself. It does not seem to be advisable to hold the present upper tow-head, but rather to dike out from the Mississippi shore to determine the continued filling of the chute below and allow the river to make a more easy curve by cutting down further the upper tow-head. The lower chute under the influence of the works above is very fast filling up.

4.—MAYERSVILLE SYSTEM.

The contraction works of this system as designed include a main dike and at least three cross-dikes on Cottonwood Bar to prevent the river cutting through next the Louisiana shore and to hold the water in the bend of Island 93, a dike across the head of the chute at Island 93, and a strong dike across the chute at Mayersville Landing. Of these works the dike across the head of the chute was constructed prior to the last annual report, and the dike at Mayersville built at high water last summer. The first of these works consists of an open dike, three rows of braced piles reaching to about the 17-foot stage and mattressed at foot; the cross-dike consists of five rows of braced piles reaching nearly to the 30-foot stage. It is expected that this last dike will cause the filling of the chute by drift-wood lodging against it. It is not yet mattressed at foot, but this will, if practicable, be completed before high water. The dike at the head of the chute passed the flood without injury and caused a very appreciable fill behind it, the chute going dry at low water both at head and foot. The dikes to be constructed on Cottonwood Bar gain in importance as the crossing at the head of the Duncansby system moves downward. A channel through this bar may endanger the dikes on the Baleshed Bar below.

5.—REVETMENT OF ISLAND 93.

At the date of the last annual report of the Commission, there had been constructed at the head of this island 1,719 linear feet of under-water mattress. After that date, until interrupted by the high water of February, 1883, the mattress-work was pushed vigorously, until it extended along the face of the island about one and a half miles. In December, also, one of the graders was put at work, and the brush-work of the upper bank revetment was followed down 1,700 feet, and partially weighted with sand-bags and stone. As the holding of the face of this tow-head is essential to the completion of the project below, the mat-work was pressed, but due to a lack of stone for sinking mats and covering the upper bank, the work was caught by the flood in an incomplete condition, some 225 feet of the upper bank revetment was lost, and the sand above the lower mat washed back from 10 feet to 300 feet back of the mattress, which remains on the bottom of the river. The work is being done over again, with nearly the same experience threatened in consequence of lack of material and money with which to complete it. On the face of this island both of the hydraulic graders have been employed to advantage, the average cost of excavation being for the last year 3¼ cents per yard, including fuel, oil, and repairs.

6.—BALESHED CONTRACTION WORKS.

From Island 93 to Stack Island extends the Lake Providence Reach proper, a stretch of straight river, on which have been built on the Mississippi side the Baleshed system of dikes. These works are designed to close the chute behind Baleshed Bar, and to extend that bar down to the head of Stack Island Chute to aid in closing also that deep chute.

The system comprises a main longitudinal dike from the main Mississippi shore near Homochitto Landing, along the crest of Baleshed Bar, to the head of Stack Island, with twelve cross-dikes so far projected and partly completed.

Of this work part of the long dike at the head of Baleshed Chute and four (partial) cross-dikes in the chute had been driven during the low water of 1882, and are reported in last annual report of work done. All the dikes of 1882 were low, reaching to the 17-foot stage on the Providence gauge. In February, 1883, work was resumed at high water upon this system, and has been prosecuted continuously to date. At high water a strong tendency on the part of the river to pass behind Baleshed Bar was exhibited and the chute began to enlarge. In resuming work at high water, to prevent this change of channel, much difficulty was experienced from drift, and many of the piles washed out as fast as driven. A lodgment, however, was at last effected, and by September of this year some 28,000 feet of pile dike had been constructed and a great fill had been secured.

Of the cross-dikes, six extend from the main dike across to the Mississippi shore, and six are still incomplete, not having been extended across the chute on account of deep water.

At the head of the system the main dike is built of three rows of braced piles, but on the highest part of the bar it is only of two rows. The cross-dikes at head are of three, four, and five rows, the better to withstand drift, and are protected at foot with thick foot-mats. The high dikes all reach to or above the 25-foot stage, and for 6 feet above the present bar surface are now being closely wattled to secure deposits of mud for the sustenance of willows, which have already begun to make their appearance.

On the decline in the river the deposits behind the long dikes were cut in channels by the water seeking the deep chute behind Baleshed Bar; in several places at head, and here also, the main dike is being closely wattled to prevent this action.

In front of the main dike a mattress, ranging in width from 100 feet at head to 60 feet at foot, has been laid to prevent longitudinal scour, and in places where the water falls through the dike into Baleshed Chute, grillage-mats have also been placed.

Along this system the local effects of main and cross-dikes can be well studied, as well as the influence of drift as an enemy or as an aid to these constructions, the cross-dikes driven at high water having caught much of it. This will be spoken of hereafter in this report.

The effect of the dikes of this Baleshed system has been all that could be expected. Although open, *i. e.*, not wattled or curtained, they have caused a great fill behind them, have extended the bar both at head and foot, and thrown the current well over to the Louisiana shore, opposite the head of Stack Island, and have perhaps rendered the permanent closure of that chute, which is now 83 feet deep at low water, a possibility in the future, the main channel of the river having already been diverted or deflected from that chute by these works, aided by the dikes reaching from the foot of Baleshed Bar to the head of Stack Island, and the short dikes on the opposite side of the river at Elton.

The proposed channel at the head of Stack Island was projected through the crest of Hopewell Bar, and the change here has been a remarkable one. The Stack Island Chute next the Mississippi shore was 80 feet deep at low water. The Elton Chute, along the opposite or Louisiana shore, was also deep, exceeding 30 feet at low water, and the Hopewell Bar filled up the greater part of the main projected channel-way.

An open dike was built above the head of Stack Island on the crest of the crossing or weir, and a series of six short spur-dikes across the head of the Elton Chute. At high water these dikes induced a deposit, as shown on the map of the April survey herewith, and the main river cut its channel to the right of the island, as projected, removing immense deposits of sand. For some time this main channel was more shoal than either of the chutes next shore, or the river ran in a trough excavated through a mound in the middle of the river. The tendency is to cut across the narrow ridge at the head of Stack Island, and to fall back into the deep trough behind that island.

The dike work so far built here, at Stack Island and Elton, is insignificant in character and must be very materially extended and made both stronger and less permeable in order to permanently keep the river out of the chute.

Although the works have been nearly altogether open pile-dikes, the effects on the reach have been very marked in deepening the channel.

During the last low water there was a good channel not less than 15 feet in depth throughout the reach, and navigation was without a hindrance anywhere.

There are attached hereto tables giving all the work done on the reach, prepared by Assistant Engineer Hider, who has also given a detailed description of all constructions used.

The machines and appliances used on the work have been the same as heretofore, with the exception of an appliance for holding the head of a mattress in swift water during construction, and until it is safely sunk to the bottom of the river. This consists of a strong truss floating at the head of the mattress, to the lower chord of which the mattress is attached every 8 feet by rings and tripping-hooks, the latter of which can all be tripped simultaneously by a rod attached to a lever at the shore end of the truss and the truss released from the mat. A modification of the hurdle-mattress has also been found necessary in the deep and swift currents encountered. This modification consists in running alongside the poles on which the mattress is woven continuous lines of iron rods, 25 feet in length, connected by lap-rings and clevises, the rods ranging in diameter from ⅜ to ⅝ of an inch. Drawings and descriptions of this mattress and mattress-head are herewith. They have been used successfully at Pilcher's Point, as may be seen from Assistant Engineer Turtle's report herewith.

The detachable mattress-head is a great assistance in sinking, without danger, the heads of continuous mats in swift currents.

Modifications have also been found necessary in the pile-dikes, which are now provided with thick foot-mats, and are built of three rows, sometimes of five rows, in all exposed places. In three-row cross-dikes the wattling is placed on the middle row, or along the middle line of the foot-mat. In five-row dikes it is proposed to wattle the second and fourth rows. The latter construction is proposed for closing chutes, the two-wattled rows representing two cross-dikes with a short pool between them, gaining the advantage of wider foot-mats and stronger anchorage over two cross-dikes of less width farther apart.

The vertical close wattling has been adopted instead of inclined mats, or curtains, as first used, on account of the greater cheapness of the construction, as less material is required. An eddy will be produced under the lip or crest of the wattling when the water passes over the wattling. At the first stages of the fill below the dikes there will be a trough immediately below the wattling, due to this eddy, but after the fill above and below reaches the level of the top of the wattled portion of the dike these troughs will evidently fill up even with the top of the general fill and the wattling be covered.

All the results accomplished on the Lake Providence Reach have been by open dikes, mostly without either screens or foot-mats. It is certain that the currents can be reduced in velocity by piles alone until they are too gentle to scour much at the foot of the dikes, and that piles alone offer sufficient obstruction to cause great fills behind them. When the dikes are mattressed at the foot there is danger that if the work is not a success the mats will remain a permanent obstruction to navigation.

It seems that it is better to secure the fill, if possible, by means which cannot by any possibility be damaging if they fail, and afterwards, with an expenditure of much less material than necessary to mattress and wattle or curtain all the dikes, to mattress only the proper parts of the new banks secured, or else in the first construction to restrict the brush work to important parts of the dikes only. The necessity for mattressing and wattling pile dikes causes great delay to the revetment of banks; causes the time, labor, material, and means to be expended to protect cottonwood piles that can last but two years at best, when our efforts would be more profitably directed to the bank work, which is more of a finality. It is my impression that no pile work is worth the extra expense of mattressing, except strong dikes placed in chutes to close them, and the main lines along the proposed new banks. Those for closing chutes should be built of cypress piles, well braced to stand any pressure that may be brought against them, heavily mattressed at foot against scour, and wattled or thickly curtained to form permeable or submergible dams.

DRIFT-WOOD.

During the early part of the rise last February, fields of drift were brought down by the flood and lodged against our piling. Most of this, on the further rise, was released and floated past, but on two of the cross-dikes on Baleshed Bar there were great accumulations. These dikes were only of two rows of piles, not provided with mats at bottom, and but insecurely braced. They were strengthened by additional rows of piles driven behind them, and the drift held by them. At first small parts of the dikes at the ends were broken away, but it has not been ascertained whether by natural scour around the outer ends of the spur dikes, or by impact of drift. The great mass of the drift accumulation was retained, and still remains above these dikes. Afterwards drift in smaller quantities lodged against the high cross-dikes in Baleshed Chute, and in one or two cases gaps were washed out in the dikes, due to its influence.

In all cases where *considerable* quantities of drift accumulated at high water there has not only not been any scour under the drift, but there has been a considerable fill, both under the drift and below it.

The action of the drift on the currents and dikes seems to be this: If in small quantities, extending a few feet only above the dike, and of moderate depth, it acts as a barrier with an aperture underneath; the head of water is increased by the barrier and the current under it directed against the bottom at the foot of the piles, which, under these circumstances, if not protected, are likely to scour out. When the accumulation gets larger the friction of the drift and bottom is more than sufficient to kill the current due to the hydrostatic head formed by the resistance of the drift to the current, flowing down upon it, and the water flowing under the drift heap runs with less velocity than before, and deposits sediment. The main body of the water then flows off along the sides of the drift obstruction, and endangers the piles on the flanks of the accumulations. A *small quantity* of drift, then, is dangerous; a *large quantity* is a help and an aid. If pile dikes are then built sufficiently strong to withstand the impact of the drift, and protected at foot sufficiently to stand the scour consequent upon the first small accumulations, this material may be made a very important part of our resources in filling up chutes and building bars.

I do not know of any case on the Providence Reach where piling yielded to *pressure* *of drift*, but there were cases where dikes were broken by the force of impact, and others by scour, caused by small drift accumulations. There are other cases where the flotation of drift is supposed to have pulled piles out as the water rose.

FINANCIAL STATEMENT.

Lake Providence Reach.

Balance from previous appropriations	$13,573 85	
Allotment under act of August, 1882	650,000 00	
New Madrid allotment (transferred)	187,500 00	
Additional allotment from unallotted reserve	112,500 00	
		$963,573 85
Expended by Captain Marshall, from July 1, 1882, to December 1, 1882:		
Plant and tools	$23,068 48	
Piles, coal, &c	3,873 15	
Services	46,061 80	
Tow-boat service	5,492 03	
Subsistence	6,968 33	
Miscellaneous	1,611 44	
Total	87,075 23	
Expended by Captain Marshall, from December 1, 1882, to November 1, 1883:		
Plant and tools	$63,766 26	
Brush, piles, &c	77,516 84	
Services: Construction	152,050 43	
Surveys	7,222 07	
Office and headquarters	10,433 64	
Tow-boats (including charter)	17,454 11	
Snag-boat	625 32	
Medical attendance (including drugs)	1,626 06	
Subsistence	22,774 61	
Miscellaneous (including transportation, traveling expenses, &c)	7,170 02	
Total	360,639 36	
Expended by Captain Marshall:		
From July 1, 1882 to December 1, 1882	$87,075 23	
From December 1, 1882, to November 1, 1883	360,639 36	
	447,714 59	
Expended by Captain Sears	359,531 33	
Total expenditures		807,245 92
Balance available November 1, 1883		156,327 93
Balance in Treasury		137,000 00
Balance in hands of Captain Sears		4,700 78
Balance in hands of Captain Marshall		14,627 15
		156,327 93

The following expenditures were made by the executive officer, Mississippi River Commission, for floating property, &c., for use on Lake Providence Reach:

Description.	Number.	First cost, each.	Total cost.	Date of payment.	Marks and numbers.
Barges	11	$2,000 00	$22,000 00	Dec., 1882, to Mar., 1883	77, '8, '9, 80, '1, '2, '3, '4, '5, '6, '7.
	8	2,400 00	19,200 00	Jan. to Mar., 1883	88, 91, 154, '5, '6, '7, '8, '9.
	2	1,960 00	3,920 00	June, 1883	59, 60.
	1	1,300 00	1,300 00	Mar., 1883	194.
	4	2,000 00	8,000 00	Not known	135, '6, '7, '8.
Total	26	....	54,420 00		
Mattress-boats	2	6,900 00	13,800 00	June to Aug., 1883	30, 31.
Steam tow-boat	1	17,404 00	17,404 00	Jan., 1883	De Pauw, now Vidalia.
Quarter-boats	4	4,000 00	16,000 00	Apr., 1883	21, '2, '3, '4.
Skiffs with oars	5	20 00	100 00	Jan., 1883	
	10	20 25	202 50	July, 1883	
	8	25 50	204 00	Aug., 1883	
Total	23	....	506 50		
Electric light and outfit.	1	938 50	938 50	June, 1883	
Anchors	....	....	865 58	Mar. to Apr., 1883	
Outfit of quarters, boats and other plant.	....	....	3,920 10	Jan. to June, 1883	
Total	....	....	107,354 68		

Barges Nos. 135, 136, 137, 138, in use on Lake Providence Reach, were paid for out of Memphis allotment; four, at $2,000=$8,000.

This list does not include plant bought for general service out of Lake Providence allotment.

REVETMENT AT DELTA POINT.

This work during the last year was carried on under the immediate direction of Assistant Engineer H. St. L. Coppée, and was a continuation of the work begun in 1878, under the supervision of Maj. W. H. H. Benyaurd, Corps of Engineers, in accordance with the recommendation of the Board of Engineers upon the Restoration of the Harbor of Vicksburg, published in the report of the Chief of Engineers for 1878.

The report of Mr. Coppée herewith is full and details at length the work done.

A description of the methods employed was given by Mr. Coppée in the last annual report of the Commission, at which time about 1,100 feet of the work was completed. From the date of that report (December 1, 1882) work progressed continuously until February 10, 1883, when the allotment had been expended. The plant was then transferred to Wilson's Point, La.

The work during the past year was carried on in the same manner as described in the former report, with the exception that the piles through the shore edges of the mats were omitted, in order that if high water should find the work incomplete, continuous mats might be sunk without interruption, overlapping the low-water mattress, and with the further exception that a mud flat some 250 feet wide, below the old bank, was not revetted above the 12-foot stage; also the upper bank revetment of the last 625 feet consisted of a woven hurdle-mat sunk at high water, reaching to the 32-foot stage, instead of the usual upper bank revetment which could not then be placed.

The work was carried several hundreds of feet below the head of the sand-bar at the point at low water.

The low water just passed revealed that the work done under the Commission stood intact, but that the mud flat mentioned above should be covered with brush and stone to prevent a possible eddy-cut around the revetted old bank.

A small portion of the dike built in 1879 at the projecting point itself has fallen in, due, probably, to the rotting away of the thick brush mats of which the dike was principally built. In all, about 500 linear feet of brush and stone patch-work should be done to secure the work against another flood. In all, about 4,000 feet of revetment measured along the bank was laid, costing, including additional quarters on shore, one quarter-boat, and the redecking of one barge, towing, superintendence, tools transferred to Wilson's Point, La., &c., $75,762.49, or $18.75 per linear foot. Mr. Coppée estimates the actual cost of labor, subsistence, towing, and material as $13.37 per linear foot, as the actual cost of the work done.

FINANCIAL STATEMENT.

By act approved June 18, 1878		$84,000 00
By act approved March 3, 1879		50,000 00
By act approved June 14, 1880		20,000 00
By act approved March 3, 1881		75,000 00
By allotments from appropriation for improving Mississippi River, August 2, 1882		50,000 00
Total		279,000 00
Expended prior to December 1, 1882		231,242 17
Balance available December 1, 1882		47,757 83
Expended since December 1, 1882:		
For plant and tools	$1,335 39	
For services	22,781 45	
For subsistence	6,318 46	
For stone and coal	12,260 92	
For charter of tow-boats, &c	3,408 37	
For office supplies	257 57	
Miscellaneous (including traveling expenses, transportation, quarters, mule hire, &c)	1,388 03	
Total		47,750 19
Balance available November 1, 1883		7 64

DREDGING IN VICKSBURG HARBOR.

Under the allotment of $100,000 made by the Commission from the general appropriation for improving Mississippi River, and the project adopted by them September, 1882, bids were solicited for dredging, and received and opened just before the date of the last annual report. An abstract of the bids received was published in the last report of the Commission.

The project for this work was to excavate a basin 300 feet wide, 1,700 feet long in front of the elevator; a canal 150 feet wide from this basin to deep water in the lake, and to keep open the west entrance to the lake. The dredging to be done to the zero of the Vicksburg gauge.

The lowest responsible bidder for this work was Mr. Rittenhouse Moore, of Mobile, Ala., 12.1 cents. The next lowest, S. N. Kimball, of Mobile, Ala., at 18¼. The third, Fobes & Co., of Baltimore, Md., at 19 cents per cubic yard. Of the three, Moore stated that he could not begin work until February 10; Kimball was not provided with plant, and Fobes & Co. expressed their ability to complete the work by June 30.

As the possible success of the entire project for the year's work depended upon the rapidity with which the work could be done, and it was especially necessary that it should be completed before the decline of the water that could be expected in July, it was recommended that the work should be divided; one-half to Moore at his bid, and the other half to Kimball or Fobes & Co., at their prices. The entire contract was awarded to Rittenhouse Moore, of Mobile, Ala., the lowest responsible bidder, who was unable to begin at the time required, prosecute the work with the vigor required under the specifications, or complete it within the time specified. The work by the contractor was not begun until April 5, 1883, and was prosecuted, with many delays, until September 18, 1883, when, on account of the rapid decline of the river, the dredging was necessarily suspended, less than one-half the required work having been performed.

For reasons to be given hereafter in this report, the contract was then allowed to expire, 350,035 cubic yards having been removed.

During the period covered by the dredging operations, the basin was excavated down to the zero of the gauge for a width of 160 feet, and four additional cuts; or 160 feet, taken down to the +5′ plane, 80 feet in width of the canal was excavated to the zero plane, and an attempt was made to excavate the West Pass, which since the previous low water had filled until the depth of cut required was about 17 feet. The attempt failed for want of proper facilities for removing the material excavated, which was of pure sand, and the work there was ordered abandoned by the construction committee Mississippi River Commission, August 22, 1883.

In consequence of the failure of the dredging operations at West Pass, and the incomplete condition of the basin, the wharf-boat was removed from the upper landing to Kleinston, August 7, 1883, when the river stood at 23.7 feet on the Vicksburg gauge, and the minor boats were excluded from the harbor a few days later, or after the river reached the 20-foot stage at Vicksburg.

On the decline of the water below the edges of the excavated area extensive sloughing and sliding inwards of the mud deposit composing its side took place, and on account of its semi-fluidity, or plasticity, the weight of the banks themselves caused an upheaval at the bottom until the slopes reached the inclination of $\frac{1}{8}$, $\frac{1}{10}$, and in places $\frac{1}{20}$. This upheaval was greatest in the deepest part of the excavation, on account of the weight of the high deposit along the Vicksburg front, which sunk down vertically from 6 to 8 feet. The upheaval here amounted to as much as 8 feet. This material was again removed to the zero plane for a width of 80 feet by the dredge prior to stopping work.

The sides of the excavated area are now quite regular, with nearly uniform slopes of one vertical to eight horizontal.

The efflux of water through the narrow and shallow cut made by the dredge at the West Pass was sufficient to keep the sand-bar cut down as the river fell, and small boats began again to make their appearance in the harbor on the first rise of three and a half feet. At the 12-foot stage steamers drawing 5 feet of water now land at the wharf-boat landing in front of the city, turn in the basin, and go out through the canal and cut at the West Pass. Larger boats, it is expected, will make their appearance at a lower stage of water than for several years. To this extent the dredging has been a success, and the benefits so far secured will probably more than repay the expenditure, if the West Pass does not fill up at once with sand on the first rise.

The rapid filling of the harbor on the declining river, as well as the unexpectedly flat slopes assumed by the sides of the dredged area, making it evident that the cost of the present project would be very materially greater than contemplated, and temporary advantage from dredging during the present low-water season being doubtful, it was recommended to the Commission that the present contract for dredging be allowed to expire on the date specified therein and the work abandoned; which recommendation was approved so far as to terminate the contract.

Early in September a survey party was organized by Assistant Engineer Coppée, and in accordance with the resolutions of the Commission passed in June, 1883, a low-water survey of the area adjacent to the proposed works was made. The results of the survey are stated in full in Mr. Coppée's report herewith.

The main facts thereby shown are these:

There has been a fill within the area covered by the proposed canal and basin ranging from five feet to twenty feet in depth, the greatest fill being near the river.

This fill within the limits of the proposed canal amounts to 1,255,486.4 cubic yards, or the amount to be removed has been increased that much by the cause mentioned in the past year.

The river has been thrown over against the bar at the West Entrance, and has cut down a deep tongue-shaped trough through the center of last year's bar, cut down its crest near the Mississippi shore, and piled up a barrier with a nearly horizontal crest across the southwest end of the lake. The tendency of the river is to cut away Young's Point and the sand-bar above Delta, and make its bend further in towards Vicksburg, lengthening its radius of curvature. This change will necessitate more extensive revetment of banks above Delta to protect the work already done. The amount of the change will not probably materially shorten the distance from Vicksburg to deep water for many years.

The increased eddy current around De Soto Island, and the consequent increased fill in the harbor of Vicksburg, results directly from the changes at Young's Point. This current will evidently increase as the water is thrown further in towards Vicksburg, until the access of water to the lake is entirely cut off by the deposit. The river is now rapidly developing its new high-water shore-line across the ends of the lake.

Soundings made in May revealed at that time an average fill of only about one foot on the Vicksburg front, so that the great fill, shown by Coppée's recent survey, took place principally on the decline of the water after June 1. This, if it always happens, is a very important fact in connection with further dredging operations in the harbor. For if the bulk of the annual fill must be removed each year after June 1, or on the decline of the river, which is always rapid, or during low water, the project to maintain continuous navigation by annual dredging would seem impracticable, for the deposit in that case does not take place before its removal is necessary, nor can it be removed much before the rise in the river in the late fall restores navigation. The most that seems practicable by dredging alone under these conditions is to prolong the season of navigation, and to hasten the return each year of the steamers to the Upper Landing.

It will therefore be necessary to introduce some scouring force, as the Yazoo River, or to effect the third and final step proposed by the Board of Engineers of 1877, in order that a current outwards may be had to prevent ingress of mud and to keep a channel scoured out.

If this is to be done by annual appropriations these appropriations must be sufficient to allow the annual fill during the progress of the work to be removed—at present rates this will cost over $200,000 per annum—and also at the same time, to avoid this recurring expense, to make rapid progress on the main work itself i. e., the excavation of the channel for the Yazoo from Old River to Centennial Lake, and from Centennial Lake to deep water in the river.

In the estimates prepared by the Board of Engineers in 1877 the cost of the diversion of the Yazoo via the dead end of Old River is placed at $1,600,000. The removal of the deposit from the line of the canal is estimated (now) to cost $766,000, with a probable annual expenditure to maintain an open canal of about $200,000, or say, if the work be done simultaneously and at once, $2,600,000. The assessed valuation of the city of Vicksburg, real estate only, was for last year (1882) $2,459,000. The present steamboat landing is about 4,800 feet below the elevator. Annual value of the commerce of the city, about $10,500,000.

There is still another scheme which finds favor in Vicksburg—as does, indeed, any plan for restoring its water front—and it is this, that since the river has now determined that Vicksburg is on the dead end of the cut off, and the expense of damming off the Mississippi mud at that end is small compared with the expense of dredging out the deposit, let the Yazoo be diverted and allowed to go out at the West Pass and a boat passage be dredged from the city front to the deep water in the then live end of the lake. This would reduce the probable expense about one-third and allow the diversion of the Yazoo to be made with advantage to the city prior to excavating the necessary basin and canal from deep water in the lake along the city front to deep water in the river, or it would make the two works independent of each other. The disadvantages of placing the town at the dead end of the cut-off are evident, but the scheme is advantageous from the above considerations and from the further fact that it is not opposed to the canal for the Yazoo ultimately along the city front, the west entrance requiring only to be stopped for one low-water season, and the canal in front of the city to be prosecuted to completion, to effect this end as proposed.

If this scheme were executed it would be advantageous to put all dredged material along the crest of the mud-bar and across the line of the proposed canal in front of the town, near Ryan's mill, to shut off ingress of muddy water, where it now requires a dam from 16 to 24 feet in height to entirely close that line at ordinary high water. The west arm of the lake, formed by the cut off, is gradually shoaling behind the bar, and here also there might be considerable dredging required before the deposit is of sufficient depth to allow a defined channel for the diverted river, or rather before the new banks of the Yazoo are formed by the contraction due to the slow deposit.

Every scheme, however, having in view the diversion of the Yazoo or the execution of a canal, involves annual dredging to maintain the proposed works. At the present mouth of the Yazoo this past low water there was only four feet of water. Boats drawing three feet struck and encountered difficulty, and it is not to be presumed that it will be deeper at the proposed mouth.

The training of the Mississippi by deflecting or silting dikes and revetments above Delta Point and at Young's Point is also proposed for the purpose of bringing the river farther in towards the town, but the cost and result of such works are still more problematical and less adapted to close estimates; the works would be tentative and costly. It is practicable, however, to maintain the river where it is, at least for many years, and it is to this work that it seems advisable to direct our efforts until doubt as to the sufficiency of the works for that end is removed.

With reference to the further prosecution of work here, then, the following propositions have been made, and are given in the order of cost:

1st. Abandon the "restoration" of Vicksburg Harbor and maintain the low-water landing at Kleinston, 4,800 feet below. This requires constant watching and care of Delta Point, and an extension of the revetment, after the bar above has cut away as far up stream as the head of the caving in this bend. All other projects also require this.

2d. Scrape or dredge the bar at West Entrance sufficiently to determine the line of cutting down due to the efflux of water during the falling stages, to allow an earlier return of vessels to the Vicksburg front. This will require also dredging in the basin and canal dredged this year to a greater or less extent, as it fills up. No estimate can be made, but it will probably not be less than $30,000 per annum after the first year. Temporary.

3d. Divert the Yazoo into Centennial Lake, and allow its current to flow out at West Pass, and keep present canal and basin dredged. Approximate cost, $1,850,000, first cost, and annual dredging in canal, basin, and West Pass to maintain it. If the high-water discharge of the Yazoo must be controlled, this estimate will be increased. This condition would make the scheme impracticable.

4th. Divert the Yazoo, close the West Pass, and dredge canal and basin in front of the city. Estimated at $2,600,000, with annual dredging at mouth of canal. Same remark concerning high-water control of the Yazoo.

The condition that the navigation of the Yazoo shall not be interfered with by the works would introduce additional difficulties in the execution of any scheme involving a diversion of the Yazoo.

The cost of any work for the permanent restoration of the harbor of Vicksburg is so great in comparison with the value of the general commercial interests involved that I am unable to make any recommendation in the matter, but the scheme for leaving Vicksburg at the dead end of the lake seems the least expensive way of affording even partial relief during declining and low-water stages. The filling in rear of the bar at the West Entrance will soon render it so wide and of such material that the outflow of water will fail to perform the work noted this year. The cutting out there during the past low water results from the fact that the bar was very narrow and of pure sand, without any cohesion whatever between its particles. When mixed with mud, like the material in rear of the bar, this cutting will be very much reduced. A widening of the crest of the bar will also have the same effect, for the increased friction may probably even convert the bar into a dam before the force of the outflow on the decline can roll the sand out of the way or cut through the mud deposits in rear.

FINANCIAL STATEMENT.

Amount allotted for dredging in Vicksburg Harbor		$100,000 00
Expended—		
For contractor's estimates	$38,118 82	
For services	5,698 32	
For advertising	105 94	
For office supplies	100 46	
For miscellaneous	498 86	
Total expenditures		44,522 40
Balance available November 1, 1883		55,477 60

CONSTRUCTION AND REPAIR OF THE LEVEES OF THE MISSISSIPPI RIVER, TENSAS AND YAZOO FRONTS.

A complete list of the levee contracts awarded by the War Department, in accordance with the recommendations of the Board of Engineers that convened at Memphis, Tenn., September 4, 1882, was published in the annual report of the Mississippi River Commission for 1882.

As the contracts were dated October 3 and October 23, 1882, the contractors had barely commenced operations at the date of the last annual report of the commission, and for that reason the entire work done under these contracts, and under the last appropriation, is reported in this report.

In the latter part of November and in December, greatly increased forces were placed upon the various works by the contractors, who, as a rule, energetically and, considering the short time during which work could be done, successfully prosecuted their works, until interrupted by the flood of February and March, 1883.

The great bulk of the earthwork had at that time been put in place, but the following-named levees were caught in an incomplete condition, and some losses were encountered:

On the Tensas front, in Arkansas, the Panther Forest levee had been completed except the sodding, and a large part of this also was in place when it yielded to the pressure during a rain-storm on February 22, and during the flood 2 miles of the 4, or about 85,000 cubic yards, washed away. The amount of funds assigned to this levee was insufficient to build it of sufficient height or cross-section to withstand the pressure of the water upon the material composing it. This was a very light, fine silt deposit from the river, which water, in its unsettled state, soon converted into a semi-fluid paste. The levee began sloughing at rear and was speedily broken through. The "retained percentage" has not been paid to the contractor. The levee would inevitably have been carried away whether the "sodding," which really is only a planting of grass sprouts at considerable intervals, had been done or not. The contractor was a planter immediately behind the levee, who took the contract to insure its timely completion.

In Louisiana, on the Tensas front, the "Wilton to Raleigh" levee, the largest and most important work of the kind in the district, was caught by the flood in an incomplete state. Of the 4 miles of the line nearly 2 miles had been untouched. The work had been purposely prosecuted so as to throw this incomplete portion of the levee behind a remnant of the old levee some 1,200 to 1,800 feet nearer the river, in order that if floods threatened wings or flanks might be thrown back to this old levee as a curtain. Immediately upon the occurrence of the great flood in the Ohio River an order was issued to the contractors to hasten the construction of these works of protection, which required some 35,000 cubic yards of earth, to complete. The upper wing was completed in time to preserve the heavy buckshot levee, closing the "Alsatia" crevasse; but the lower, closing the Edgwood and Illawara crevasses, was carried away in a wind and rain storm during the night, and there resulted to the contractor a loss of about 32,600 cubic yards of earthwork. The river having determined a new channel through the chute of Island 97, the wings, proposed last winter as protection works, are now made parts of the main line, the old levee in front being enlarged and used also as part of the main line.

"Omega to Milliken's bend" levee, Louisiana, another large and important work, was also in an incomplete condition, and the saving it was rendered still more difficult by the fact that water collected behind the levee, which, with the river pressing in front of it, cut off a supply of material with which to raise it. Barges were sent down from the works at Wilson's Point, and by strenuous efforts the top of the levee was kept above water by material transported from a distance, and the entire work saved.

Also at "Delta to Bedford's" levee, six miles in length, a gap of 1,100 feet was untouched. Backwater from the Diamond Island crevasses shut off access to it, and the water began running through low places in the banks in front. Here a line of protection levee, nearly three miles long, along the edge of the river bank was built, which, as soon as the situation allowed, was reduced in length to about one-half by a cross-levee to the main work, built by hired labor. This long line several times gave way in places, but the gaps were in each case promptly closed, and the work saved.

On the Yazoo front, in Mississippi, the flood found the levees in such condition that all were entirely safe, except the Longwood, Skipwith, and Elleslie levees, at each of which protection levees were built.

That at Elleslie gave way from a storm dashing waves against it, and the water broke through the incomplete main line, flooding several plantations and washing out 2,600 cubic yards of earth from the main levee. This break was more advantageous than otherwise to the flooded lands. The banks are high, and the water on the first decline of the river was soon excluded by a second protection levee along the site of the first.

Appended hereto are reports of Assistant Engineer H. D. Garden, in charge of the levees on the Tensas front in Louisiana, and of Assistant Engineer George M. Helm, in charge of the Yazoo levees in Mississippi, which give in condensed form information concerning the levees built in the district.

As the latter gentleman has been chief engineer of the Mississippi Levee Board for the past two years, and has had much experience in levee construction, he was requested to give in his report, for the information of the Commission, a statement of the work done by the levee district authorities during the past eighteen months, and also to submit the best practice, as shown by his experience, in stopping crevasses, building heavy levees on unstable foundations, and revetting the ends of breaks to prevent enlargement. Both gentlemen submit estimates for raising the levees in their charge to 3 feet above high-water mark of 1882.

There are also submitted with this report tables showing earthwork built in the district to March 1, 1883, or in four months prior to the flood, and the condition of the levee work under the various contracts November 1, 1883, the date of this report. From this latter table it appears that there has been built in all, including the small amounts returned in last annual report:

	Cubic yards.
Tensas front, Arkansas	243, 428. 0
Tensas front, Louisiana	1, 001, 734. 0
Yazoo front, Mississippi	1, 193, 281. 1
Total	2, 438, 443. 1

and that there remains to be done—

	Cubic yards.
On the Tensas front in Louisiana	99, 381. 6
On the Yazoo front	14, 627. 0
	114, 008. 6

It is expected that work will be completed and contracts closed by December 1, 1883.

In all cases the grades of the levees have been restricted to the grades of the old levees, except at Wilton to Raleigh where the bank was exceptionally low, and the levee of very difficult construction, from the nature of the material.

Another break here would make it still more difficult and costly to rebuild the levee, and would allow enormous quantities of water to escape from the channel, the ill effects of which on navigation are now seen just below the present crevasse, at Foster's.

For these reasons, the grade as established for this levee was placed at about 18 inches higher than that of the levees immediately above and below, which were on high ground, and the levee across the sandy part of the line built of increased dimensions.

FINANCIAL STATEMENT.

Tensas front.

To amount allotted			$323,840 00
To amount transferred from Yazoo front			25,000 00
To amount redeposited on account of error in voucher 45			1 00
Total			348,841 00
Expended prior to December 1, 1882:			
Contractor's estimates	$28,888 06		
Services	2,616 05		
Instruments	1,319 35		
Subsistence	177 93		
Miscellaneous	637 20		
		$33,638 59	
Expended from December 1, 1882, to November 1, 1883:			
Contractor's estimates	$239,531 20		
Services	10,372 11		
Services on protection levees	4,662 79		
Instruments	282 75		
Subsistence	135 69		
Office supplies	357 42		
Miscellaneous (including bags used on protection levees)	2,176 94		
		257,518 90	
Total expenditures			291,157 49
Balance available November 1, 1883			57,683 51

Yazoo front.

To amount allotted			$359,050 00
By amount transferred to Tensas front			25,000 00
Balance			334,050 00
Expended prior to December 1, 1882:			
Contractor's estimates	$28,435 49		
Services	1,511 00		
Miscellaneous	112 61		
		$30,059 10	
Expended from December 1, 1882, to November 1, 1883:			
Contractor's estimates	$266,749 89		
Services	12,504 33		
Services on protection levees	1,082 73		
Office supplies	304 50		
Instruments	170 60		
Miscellaneous (including bags used on protection levees)	2,965 17		
		283,777 22	
Total expenditures			313,836 32
Balance available November 1, 1883			20,213 68

Tabular statement showing amount of earthwork constructed on levees, third district, before the flood of 1883, *and amount constructed since then to November* 1, 1883.

Name of levee.	Total amount in levee. Approx.	Amount constructed March 1, 1883, date of expiration of contracts.	Amount constructed since March 1, 1883.	Amount yet to be constructed.
TENSAS FRONT.	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*	*Cubic yards.*
Delta to Bedford, La	243,903.3	182,739.0	61,164.3	
Protection levee (approx.)		20,000.0		
Sparta above Duckport	39,156.9	39,156.9		
Milliken's Bend to Cabin Teele	90,002.2	90,002.2		
Omega to Milliken's Bend	199,059.2	156,032.6	43,026.6	
Raleigh to Willow Point	41,287.7	41,287.7		
Wilton to Raleigh	* 387,941.8	225,495.0	63,065.2	99,381.6
Protection levee		16,572.0		
Lake Providence Reach	61,162.9	61,162.9		
Protection levee		2,029.6		
Duffin's Break, Arkansas	80,246.0	80,246.0		
Panther Forest, Arkansas	163,182.0	163,182.0		
	1,305,942.0	1,077,905.9	167,256.1	99,381.6
YAZOO FRONT.				
Magna Vista to Chotard	49,357.0	49,357.0		
Shiloh to Tennessee	67,299.1	67,299.1		
Elleslie	133,500.0	104,627.9	28,872.1	
Protection levee		2,796.0		
Skipwiths	71,660.0	63,067.0	8,593.0	
Protection levee		3,500.0		
Longwood	75,891.0	60,041.0	15,850.0	
Protection levee		15,978.0		
Jenkins to Easton	58,631.0	31,017,0	20,270.0	7,344.0
Rolands to Jenkins	156,213.0	155,149.0	1,064.0	
Clay and Baggots to Rolands	103,298.0	95,148.0	867.0	7,283.0
Wade Breaks	50,714.0	50,112.0	602.0	
Hughes Breaks	22,882.0	22,882.0		
Beulah to Hughes	150,538.0	139,797.0	10,741.0	
Beulah enlargement	66,836.0	66,836.0		
Beulah Breaks, 1 to 9	27,152.0	27,152.0		
Riverton Breaks	151,663.0	151,663.0		
	1,185,634.1	1,106,422.0	86,859.1	14,627.0

* This amount includes 31,552 cubic yards, which was washed away during flood of 1883. It has not yet been decided by the Second Comptroller of the Treasury whether this quantity will have to be put up again by the contractors, at their expense, or paid for by the Government.

Owing to a new location of the levee, the amount of 13,302.1 cubic yards already paid for was thrown out of the main line of levee.

The actual amount in this levee when completed will be 343,087.7 cubic yards.

LEVEE SURVEYS THIRD DISTRICT.

Under an allotment of $1,000 made by the Mississippi River Commission at their meeting in November, 1882, a party was organized September 20, 1883, by Assistant Engineer W. L. Starling for the survey and location of levees in Arkansas from the high land on the east side of Amos Bayou, 7 miles back from the river and about 16 miles above Arkansas City, to the Louisiana State line.

The field work of this survey was completed November 1, 1883, and Assistant Starling is now engaged in the calculation of volumes and in plotting the profiles and necessary new locations of the line where broken.

In accordance with the request of the president of the commission the notes of the survey from Amos Bayou to Arkansas City have been reduced, and the line from Amos Bayou to the river plotted. These estimates show the following results:

	Cubic yards.
Necessary to build and repair the O'Possum Fork levee up to the high-water mark of 1882	351,325.0
To 1 foot above high-water mark of 1882	483,783.0
To 3 feet above high-water mark of 1882	846,919.0

These estimates considerably exceed that made for the Board of Engineers which convened at Memphis, September 4, 1882, but have been deduced from careful survey. More than one-half the water that escapes into the Tensas Basin flows through the gaps above Arkansas City, and there is now an effort being made by the State of Louisiana, corporations, and private individuals in Arkansas to the effect closure of this line, and a contract for the work has been made by them. If the reduction of the notes can be made in time the results of the survey will be incorporated in this report before finally submitted to Congress.

FINANCIAL STATEMENT.

Amount allotted		$1,000 00
Expended:		
Instruments and outfit	$51 75	
Services	386 66	
Subsistence	35 50	
Miscellaneous	23 05	
		496 96
Balance available November 1, 1883		503 04

SURVEY OF CHOCTAW BEND REACH.

At the date of the last annual report of the commission the survey party under Assistant Engineer William T. Blunt was in the field. The survey was begun November 17, 1882, and completed and the party returned to Wilson's Point December 30, 1882.

The survey was restricted to the hydrography proper, the shore line as determined by Assistant Engineer Ockerson the preceding year being accepted, except where caving banks rendered new locations of shore lines necessary.

The survey extended from Cook's Point to Arkansas City, a distance of 28 miles. The survey shows that there was not less than 13 feet of water at a stage corresponding to a gauge reading of zero on the Arkansas City gauge, or that there existed no obstruction to navigation in 1882, low-water season.

A complete project for the improvement of the reach will be submitted with the maps at the earliest practicable moment. For the present there is no especial demand for its improvement, except the revetment of the upper and lower banks of Cook's Point neck, where it is caving and a cut-off imminent. This requires 7 miles of revetment, at a probable cost of $515,000, if carried to the top of the bank, or $210,000 if restricted to a subaqueous mat. The caving is now back to the cypress swamps, and the material is, as usual in slowly-deposited banks, heavy buckshot, very tough and difficult to cave. The banks, however, are wearing quite rapidly, and the configuration of the river points to a cut-off. The neck now is nearly a mile wide, but low, the water flowing across at several feet below the ordinary high water. At the up-stream side of the neck is Persimmon hollow, leading into Long Lake, which occupies the middle of the neck, and drains out through Cypress Bayou, on the lower side of neck. The danger lies in this low depression, already sufficiently lowered to cause quite a deep channel-way across at high water, obstructed, however, by a thick undergrowth of cypress, willow, and cottonwood, and accumulated drift-wood.

The report of Assistant Engineer Blunt is herewith.

FINANCIAL STATEMENT.

To amount allotted		$4,000 00
Expended:		
For services	$1,587 92	
For subsistence	495 06	
For tools and supplies	531 36	
Miscellaneous	65 52	
		2,679 86
Balance available November 1, 1883		1,320 14

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REPORT OF ARTHUR HIDER, ASSISTANT ENGINEER, UPON OPERATIONS OF THE LAKE PROVIDENCE CONSTRUCTION PARTY.

WILSON'S POINT, LA., *November* 15, 1883.

SIR: The following report of operations of the Lake Providence construction party from December 1, 1882, to November 1, 1883, is respectfully submitted.

The work undertaken in accordance with your instructions, and that which has so far been executed, has had in view the following objects:

The narrowing of the width of the river in places where it was excessive, to bring the regularized channel within the boundaries fixed in accordance with the original project, by the following methods, viz:

First. The closing of the Duncansby and Skipwith chutes by the construction of a system of pile dikes at and near the head of the Duncansby chute. The filling up of the steamboat channel, which was between the upper and the lower towheads, by the construction of a pile dike joining the two bars and the concentration by this means of the water on the right of the towheads, so as to permanently fix the channel next the Louisiana shore and prevent the further caving of the banks in the Skipwith chute.

Second. The closing of the Mayersville chute by a pile dike across the head, and others in the chute further down, and the protection of the channel side of Mayersville Island by the construction of willow mattresses and revetting the front face of the island to prevent further caving, so as to retain the channel of the river in its present location.

Third. The closing and silting up of the chute between the Baleshed Bar and the Mississippi shore, and the prolongation of the Baleshed Bar at its upper and lower extremities by a system of dikes placed longitudinally and normal to the direction of the current, for the purpose of restricting the width of the river along the Vista and Longwood fronts within such limits as would afford a good channel at all stages and prevent the river crossing to the Mississippi side into the Baleshed Chute.

Fourth. The closing of the main channel of the river, which passed between the foot of Baleshed Bar and the head of Stack Island, and bringing it back to the right of Stack Island by a system of deflecting dikes located on the Louisiana side at Elton Bar, and a longitudinal dike, driven across the channel between the lower end of Baleshed Bar and the head of Stack Island, so as to prevent further caving on the Mississippi shore behind the island, which had already done a great deal of damage and was increasing at an alarming rate.

The objects sought to be obtained at all these points have, to a great extent, already been accomplished, as shown by comparative soundings and surveys furnished by the survey party, which accompany this report.

The lack of stone to properly secure the revetment work done in November and December of last year along the face of Mayersville Island, was the cause of the caving of the bank in rear of the mattress work. This would, no doubt, have been prevented had material been available to properly secure the work.

DESCRIPTION AND EFFECTS OF WORK DONE.

Duncansby chute.—During last season a system of low-water dikes was constructed at the head of this chute, the two upper dikes and the main dike at the head consisting of two rows of piling, securely braced. These dikes were provided with light brush foot-mats, loaded with stone, laid between the piling, and had screens or open hurdle work placed in front of them.

The three lower dikes across the chute consisted of single rows of piles with screens or open hurdle work in front.

All these dikes did good service and caused a heavy deposit in the chute during the high water; in many places the fill extended to the top of the piles.

The main dikes A and B built last season, connecting the upper and lower towheads, accomplished the result desired, viz, the filling up of the steamboat channel, before existing between the upper and lower towheads; the fill here also extended nearly to the top of the piles. The two bars are now one, and even at high water there is no channel between them.

There has been a general enlargement of the bars in front of Duncansby, and a shoaling of the chute along its whole length. At low water this season a skiff would not float between Duncansby and Skipwith Landing, and at the head of the chute the bar was entirely above water, no water at all entering the chute at the upper end. Skipwith Landing was moved down nearly a mile nearer the mouth of the chute on account of shallow water, to enable steamboats to deliver freight.

On account of the rapid caving which took place during the high water in the bend above Pilcher's Point, deflecting the main current across the river immediately above and against the dikes at the head of the chute, seriously threatening the work heretofore put in, and together with the rapid caving back of the upper Duncansby towhead, which had been left unprotected; in accordance with your direction, four additional dikes, Nos. 5, 6, 7, and 8, were driven during the high-water stages across the chute, extending as close to the shore as the depth of the water would permit; dike No. 6 consisting of three rows of piles, with a woven mattress 130 feet in width, made in sections of from 100 to 200 feet, overlapping each other, sunk in rear of the dike.

The two lower dikes, Nos. 7 and 8, were provided with thick grillage mats between the piling. These dikes, where the water was shallow, consisted of two rows of piling securely braced, and where the water was of greater depth than 15 feet of three rows. In addition to these precautions a protection dike with a woven mat 100 feet in width, with a screen hung in rear, was driven immediately in front of the caving towhead, and afterwards a mattress placed across the head, lapping around the towhead, was constructed. On the inside the mattress was badly broken up in sinking on account of the bluff bank. This work failed to hold the towhead and has been swept away. The whole force of the river at high water was against the head of the towhead, which is of sand. The dikes put in withstood the high water and show a fill behind them. Gaps were washed out in the low-water cross-dikes constructed last season where they joined the main dike, and also in those further down in the chute; part of this main dike was also scoured out, the channel at low water being in close proximity to the remaining part. The piles were removed so as to leave as wide a channel as possible.

The effects of this system of dikes is shown in plate herewith, in which the surveys of February, 1882, and October, 1883, are compared; the bar lines are shown at low-water stage, viz, 1′.5 on Lake Providence gauge. For location of dikes, &c., see accompanying map.

Mayersville Island and Chute.—During last season a woven mattress from 100 to 130 feet in width was constructed along the face of the island, beginning at the head and extending down 7,500 feet. The bank was graded by the hydraulic graders, and the upper 1,550 feet revetted on the channel side, the revetment lapping around the head and extending down the chute side about 350 feet. The revetment was constructed by placing a layer of brush along the slope, which was held in position by stakes driven in the bank, to which stringers or binders holding the brush together were securely fastened with wire.

Behind the greater part of the mattress the slope had no protection at all, as it was impossible to get brush and stone in sufficient quantities to finish this work before the high water.

The effect of the high water on the face of this island, which had before been caving rapidly, was, except for about 1,800 feet at the head where the revetment had been partially covered with stone, or held down by sacks of sand, to cave the bank behind the mattresses. The caving has extended from 50 feet at the upper end, to 500 feet at the lower end, back of where the original mattress was sunk, and has rendered necessary the construction of a new mattress along nearly the entire length of the face of the island, which is now in progress. The cause of the caving back of the island was undoubtedly from the fact of not having sufficient brush to complete the revetment, and stone to hold the bank protection in place, as the island itself is composed nearly altogether of sand.

Had it been possible to have finished the revetment and covered it with stone behind the mattress work as it progressed, it is believed that further caving back of the island would have been prevented. The low-water dike built across the head of Mayersville chute has remained intact, not a break having occurred. The dike here shows good results by the shoaling of the water behind it and the enlargement of the bar at the mouth of the chute, and the increase in size of the towhead near the head of the island.

Further down, the chute has deepened at some places, and in order to prevent further scouring, in accordance with your instructions, dike No. 1, consisting of five rows of piling securely braced, was driven across the chute opposite Mayersville Landing to aid the main dike at the head in filling up the chute. Dikes 2, 3, 4, and 5, built the previous season in the chute, were only partially completed; no particular effect has been observed from the action of these dikes; they are located too far down to aid much in filling up the chute. A sketch showing the condition of the works, November 1, 1883, in this locality is shown in map herewith.

Baleshed Bar and Chute.—The work at this point has been the construction of a main dike extending from the Mississippi shore below the front of Mayersville down the river 15,000 feet, reinforced by a system of cross-dikes between the main dike and the shore. Dikes 1, 2, 3, 4, and 5 at the upper end, extending to the Mississippi shore, the parts of dikes 4 and 5 nearest the bank, as well as part of 10 and 11 and the whole of 12 were constructed as low-water dikes, part of the main dike between cross-dikes 1 and 4 is also a low-water dike. These dikes were built previous to December 1, 1882, and stood during the last high water with little damage. They are shown on the sketch by dotted lines. The cross-dikes from 1 to 7 have thick grillage foot-mats constructed between the rows of piling, held in place by rock, or the mats fastened to the piling by stringers spiked to them and weighted, and held in place temporarily with bags filled with sand, until a supply of rock can be obtained, and the river is at a high enough stage to allow the stone to be floated on barges to the dikes. The pile-driving done this season at this locality was during the high water, and these dikes may be considered as high-water dikes. The upper part of the main dike has been wattled from cross-dike No. 1 to the Mississippi shore along the middle row of piling up to the 20-foot stage; also dike 1. This work is being continued down from the head of the system, as rapidly as possible. A woven mattress from 40 to 100 feet in width has been constructed in front of the main dike from No. 4 cross-dike to No. 11, to prevent scour. The dike when not provided with a woven mattress in front will have a thick grillage foot-mat constructed between the rows of piling, which is now being done. This will complete the work as laid out at this locality in accordance with your instructions. The general effect of the work here has been—

1st. The enlargement of the Baleshed Bar, both in size and height, and the lengthening of the bar by accretions, both at its head and at the foot.

2d. The filling up of the Baleshed Chute at its upper end, and the enlargement and deepening of the channel along the Vista and Longwood fronts.

3d. The prevention of the threatened crossing of the river between the foot of Mayersville Island and the head of the Baleshed Bar, behind the bar, and down the Mississippi shore.

4th. The filling up of the old crossing between the foot of the bar and the head of Stack Island. For location, &c., of this work see accompanying map.

Stack Island.—In order to force the main channel of the river, which flowed down the Stack Island chute, on the outside and along the face of the island between it and the Elton Bar, a main dike consisting of two rows of piles was driven from a point below the foot of Baleshed Bar to the head of Stack Island, leaving the low-water channel from Longwood through the Stack Island chute open for the passage of boats. This dike was driven as a low-water dike; a grillage foot-mat was constructed between the piles, beginning at the head, as far down as could be put in before the high water covered the dike. During high water this work showed good results, forcing the main channel of the river to the right of the island and building a bar to the head of Stack Island, as shown by the high-water survey of April, 1883. As the river fell to low-water stage the difference of slope on the chute side and the main river was so great, caused by the system of dikes at the upper end of Baleshed preventing the water from freely entering the upper end of the chute, as to render the current extremely rapid through this dike, resulting in cutting off the top of the bar in front of the dike, and finally carrying away part of the dike near the head of Stack Island. This was replaced and again broken by a sunken barge lodging against it. The break has again been repaired and a grillage foot-mat sunk between the rows of piling. The current passing across the head of Stack Island will be materially lessened as the river rises, and the slope on both sides of the island is more nearly equalized. A channel across the head of Stack Island is not anticipated, as at high water the works on Baleshed Bar above, will be sufficient to cause the bar to again form at a greater height than before, and it is believed entirely stop any water passing into the chute at this point at next low water. For location of dike-work see map herewith.

Elton Bar.—The work here consisted in the construction of a main dike and six short cross dikes, at the head of Elton Bar and in the chute, to act in deflecting the channel across the river toward the head of Stack Island, auxiliary to the Stack Island main dike, and to close the chute, which was rapidly enlarging, along the Louisiana shore and caving the banks at a very rapid rate, and thus concentrate the water in one channel; as when the works were put in it was difficult to determine which of these channels the river would take, behind Stack Island, along the Louisiana shore, or whether it could be concentrated between Stack Island and the then large Elton Bar. Parts of these dikes were carried away by drift during the high water, but not before they had accomplished the desired result. For location of these dikes see map herewith.

METHODS OF CONSTRUCTION.

Dike work.—No material change has been made in the methods employed in the construction of pile dikes from those of last season. The principal change has been in making the dikes of a greater number of rows of piles. The distance between the rows has been increased from 10 to 15 feet in deep water to allow of more secure bracing as well as the thickness and width of the brush work laid at the foot of the dikes to protect them from the actions of the current and prevent scour. The experience of last season's work showed conclusively that the strongest form of construction is required in order to withstand the force of the current at high water, and has led to putting in work of greater strength where exposed to the action of drift.

Pile driving and bracing.—The plan pursued in building pile dikes has been to drive the front and rear rows of piles simultaneously when it could be done, fasten the longitudinal stringers to the piles, and complete the dike by putting in place the cross-braces. In all cases the longitudinal and cross-braces, in addition to being fastened to the piling with spikes, have been well wired with No. 8 wire passed around the pile and across the brace diagonally from the upper to the lower edge, and made taut by twisting. This was rendered necessary on account of the material used for both piles and braces, which is almost entirely cottonwood; but few cypress piles have been used. The piles have been sunk as deep as possible, generally from 15 to 20 feet, depending upon the nature of the bottom. Two forms of bracing have been used, as shown in the sketches, one with rods, for dikes constructed at high-water stage, and the other for dikes built during low water. These are the same methods used, in accordance with your directions for last season's work, and have answered the purpose well; experience has suggested no improvement upon them. The piles have been sunk by the use of a jet of water forced through a 1½-inch gas pipe, leading down the side of the pile, and by the aid of quick blows from a hammer of 2,000 pounds falling through a distance of about 6 feet.

Two forms of pile-drivers have been in operation, one with the leads placed in front of the boat, and the other with the leads on the side. The first form is preferred for general use, especially for cross-dikes and in rapid currents, as being found more convenient to keep in position and handle, and for this reason accomplishing more work. One of the side-lead drivers has been in operation, and has done fair service. These drivers are provided with large boiler capacity and pumps capable of discharging more water under a greater pressure. Piles can be sunk deeper with these than with the others, but the difficulty of handling them in cross-currents reduces their efficiency.

Between 15 and 20 feet has been the average depth of penetration obtained; after reaching that depth, if further sinking is not stopped by gravel, buckshot, or other hard material, the frictional resistance exerted by the sand along the side of the pile generally prevents further penetration. This resistance could not be overcome either by the use of the water-jet or the hammer, or both combined, as the wood of which the piles are composed will not withstand, without splitting, the shock of the hammer falling from a great height. The usual method has been to sink the piles with their large ends down; the butts are cut off square, and are about 18 inches in diameter, the small ends not less than 10 inches diameter, and the length of the piles from 35 to 50 feet; about ten piles is counted as an average day's work for one driver with a crew of seven men, consisting of a foreman, engineer, and five laborers. No special improvement in the methods followed in pile sinking or in the construction of drivers has suggested itself. They are well adapted for the purposes for which they were designed. Four different kinds of hoisting engines are in use, each of which has an advantage in some particulars over the others; on the whole the small horizontal engines have given the best results, being quicker in operation, and, next to the ordinary crab in use on four of the drivers, costing less for repairs on account of breakage.

Brush mats, hurdles, &c.—The principal dikes have been protected at their foot to prevent scouring out, by constructing mats formed of two, three, or four layers of brush, depending upon the importance of the dike, rapidity of current, depth of water, and danger of cutting out. These layers of brush are placed alternately crosswise and parallel with the dike. Stringers, or waling-pieces, as binders, are first hung from the piles as a framework for the brush to be laid upon. When the mat is of sufficient thickness other binders are laid on top of the mat connected with those underneath by wires at suitable intervals, leading up from the under stringer pieces, twisted together so as to make the construction as close as practicable. The brush is laid so as to extend through the rows of piles, requiring on some of the dikes three lengths of brush, the brush ends overlapping the butts. When finished, the mat extends both in front and rear of the dike from 10 to 15 feet outside the dike. The grillage mats thus constructed are then sunk in place by being loaded with rock taken to the dike on barges. When woven mats are placed in front of dikes to prevent longitudinal scour they have been built similar in construction to the large mattresses used for the protection of caving banks, and sunk in place by being loaded with rock. For the purpose of preventing the threatened deepening of the Duncansby chute during high water, a brush foot-mat 130 feet in width, made in sections of from 100 to 200 feet in length, was woven on a mattress barge in rear of dike 6, which extends across the chute near the head. Alternate sections were built and sunk. The intervening ones were then constructed so that when in position on the bottom they overlapped the sections previously built about 10 feet, thus forming a continuous brush foot-mat 130 feet wide immediately in rear of dike. The dike itself was constructed of three rows of piles securely braced. In order to insure the mats, when sunk, being close to the dike a strong stringer was spiked and wired across the ends of the weaving poles, which were allowed to extend through the dike beyond the rear piles, thus forming a crib around each pile. Before sinking, the mats were covered with stone, evenly distributed, the upper side of the mat being lowered to its place by the aid of lines fastened to the front row of piles, which were slacked as the mat went down, so as to keep it in a horizontal position. The only curtain construction used this season was that placed in rear of the protection dike built in front of the upper Duncansby towhead. This was of the usual form of woven work, built so as to allow of about one-foot spaces between the brush. It was sunk by fastening sacks of rock to the curtain, to counteract the force of the current and hold it in position.

The wattling or hurdling has been made close by forcing the pieces of brush down so as to be in contact with each other, and has been done on either the middle or front row when the brush mats are built between the rows of piling so as to provide against the effect of the overfall cutting out the sand in rear of the dikes. Sketches giving details of the different forms of construction employed in the dikes built and their location is shown on map herewith.

The following statements furnished by Assistant Engineer C. P. Ruple, gives in detail, in tabulated form, the work done in dike construction; also an estimated cost for labor for the different classes of work, and amount of material required. All the pile-driving done has been under his charge, and since June 1, 1882, at which time the foot-mat party under Assistant Engineer E. D. Thompson was consolidated with the pile-driving force, this class of work also.

Statement showing dike work from December 1, 1882, *to November* 1, 1883.

Location.	Dike.	Feet driven since December 1, 1882, standing November 1, 1883.	Washed out and replaced during construction.
Duncansby	Duncansby Bar protection.	....	340
Do	Main dike A	....	250
Do	No. 1	100	....
Do	No. 3	150	....
Do	No. 5	545	....
Do	No. 6	2,105	275
Do	No. 7	2,061	....
Do	No. 8	2,310	....
Mayersville	Main dike	2,300*	....
Do	No. 1	805	....
Balesbed	Main dike above 1	1,991	....
Do	Main dike from 3 to 7	2,837	1,021
Do	Main dike from 7 to 11	6,905	....
Do	No. 1	933	....
Do	No. 2	1,192	....
Do	No. 3	1,172	....
Do	No. 4 of 1883	661	469
Do	No. 5 of 1883	983	153
Do	No. 6	1,452	150
Do	No. 7	1,204	500
Do	No. 8	1,011	150
Do	No. 9	1,097	....
Do	No. 10	924	....
Do	No. 11	894	....
Do	No. 12	583	....
Stack Island	Main dike	5,250	1,429
Elton	Main dike	943	857
Do	No. 1	746	54
Do	No. 2	887	63
Do	No. 3	975	....
Do	No. 4	300	356
Do	No. 5	484	40
Do	No. 6	435	....
Totals	....	44,235	6,432

* Three hundred feet of this dike is incompleted.

Of the above dike there is in—

Single row	2,336
Double row	25,187
Three rows	14,150
Four rows	565
Five rows	1,997
Total	44,235

Statement showing cost of different items of work, and material required in dike construction.

Amount of pay-roll	$89,771 07
Subsistence	19,991 06
	109,762 13
Labor loaned other parties, with subsistence	333 60
	109,428 53
Distributed as follows:	
1. Pile driving—driving, bracing, and stringing	$78,897 93
2. Brush work—foot-mats, wattling, shore-mats, screens, &c., making and sinking	30,530 60
	109,428 53

Number linear feet dike driven—all kinds, $50,667—cost $1.557 per linear foot; equivalent to 60,947 linear feet double dike—cost, $1.294 per linear foot.

Number linear feet dike driven—as it stands, 44,235—represents a cost of $1.783 per linear foot; equivalent to 53,703 linear feet double dike—represents a cost of $1.469 per linear foot.

Number linear feet dike driven—washed out—all kinds, 6,432; equivalent to 7,244 linear feet double dike.

Total number of piles driven, 15,553; average cost per pile, $3.45	$53,800 08
Total number of braces put on, 8,230; average cost per brace in place, $1.65	13,579 50
Total number of stringers hung, 4,517; average cost per stringer in place, $2.55	11,518 35
	78,897 93

Greatest number of piles driven by one driver in one day, 15 to 22 feet of water—45 feet piles used—depth of penetration 17 to 20 feet, was	22
Number pile-drivers in commission December 1, 1882	11
Greatest number in commission at any time	16
Average number drivers per each day in commission	13
Cost per 100 square feet woven foot-mat, making and sinking, 60 feet wide	$1 32
Cost per 100 square feet wattling	2 00
Cost per 100 square feet foot-mat, between piling, made and sunk, from	$1 50 to 1 95
Cost per linear foot of dike, woven foot-mat, making and sinking, 130 feet wide	1 65

2 coils wire are required to brace and string 100 feet double dike.

1 cord brush makes 100 square feet foot-mat between piling.

7-10 cord brush makes 100 square feet woven foot-mat.

From the above statement the cost of a linear foot of dike, consisting of two rows of piling complete, with brush work, is estimated as follows:

Labor cost as above:		
Pile work for 100 linear feet		$146 90
Brush work, grillage foot-mats., 50 feet wide		86 25
Wattling, 10 feet high		20 00
Total labor cost		$253 15
Add cost of material:		
26 piles, at $2.00	$52 00	
21 braces and stringers, at $.90	18 90	
50 cords brush, at $1.75	87 50	
30 cubic yards stone, at $2.00	60 00	
Wire and spikes	27 60	246 00
		$499 15
Add estimated cost of local tow-boats for charter, repairs, wages, and subsistence, two-thirds charged to dike construction		40 46
Total estimated cost of 100 linear-feet dike		$539 61

or $5.40 per linear foot. This will be increased to $6.72 if a woven foot-mat, 100 feet wide, is placed in front of the dike in addition to the grillage foot-mat. For a dike of two rows of piles, with a 130-feet woven foot-mat in rear, and grillage mat 50 feet wide between the piling, the cost per linear foot is $7.05. Allowing for contingencies, such as increase in price of material and wages, a fair estimate would be $6.00, $7.40, $7.75 per foot for each class respectively.

BANK PROTECTION.

Mattress construction.—The usual form of mattress construction has been followed, the willows, from 2 to 3 inches in diameter at their larger ends, and from 30 to 50 feet in length, are woven on large cottonwood poles from 3 to 4½ inches diameter at small end, placed about 8 feet apart on ways or skids erected on a boat for that purpose. They are pushed down the skids close together over and under alternate poles forming woven work, then brought into close contact by driving the brush together with heavy wooden mauls. Alongside of every weaving pole or alternate poles, determined by the width of the mat and the longitudinal strength required, iron rods with welded eyes at each end are placed as the mat is built; the ends of these rods are connected with lap-rings or clevises. These rods are to give the necessary longitudinal strength to the mat, and prevent it breaking asunder while being sunk, and allow it to adjust itself to any irregularities on the bottom. The mat is then further strengthened by binders made of poles placed on top, securely fastened to the mat with wire to the weaving poles.

In wide mats, and where the current is swift and the water deep, additional longitudinal strength has been obtained by the use of No. 8 wire twisted in the form of a cable, extending on top of the mattress, securely fastened at intervals by wire to the weaving poles. The upper end of the mat while being constructed is held in place by lines passed under a mooring barge leading to fastenings on the shore above. The mooring barge is placed with one end next the bank, the outer end being kept in place by lines leading to suitable fastenings on shore. The head of the mat is held up by small lines passing over the side of the mooring barge, to which they are fastened, which are slacked as the head is sunk; additional lines leading from the mat to the bank are placed along the mat at intervals, so connected with it by iron clevises as easily to be freed after the mattress has been sunk in position.

The use of the mooring barge is to prevent drift from lodging on the head of the mat, and to keep it from being submerged until it is ready to be sunk. The mats have been sunk by first loading the edge next shore along the slope, with rock, and afterwards by throwing rock on it, beginning at a suitable distance below the head to allow the mat to reach the bottom without breaking. The head is then sunk last.

A great deal of trouble and some loss has been experienced in sinking large matresses. Experience has shown that in deep water and where the current is swift the mat can hardly be made too strong, and should not be of a greater length than from 600 to 800 feet, as the frictional resistance offered by a mattress of, say, 150 feet in width of this length is enormous, and renders the greatest amount of care and precaution necessary to prevent loss. The methods employed heretofore in sinking large mattresses are not entirely satisfactory, as there is always danger of their loss when the current is swift and the water is deep. The irregular supply of stone has led to the construction of greater lengths than otherwise would have been built, in order to keep the men employed.

Grading.—After sinking the mattresses in place the bank has been graded by the hydraulic graders to a uniform slope of from 2½ to 3 to 1, ready for the brush revetment; but little hand-work is required to trim up the bank, except where it is of sand. The following is a description of the plant and how operated, furnished by Assistant Engineer Henry Steubing, who has had charge of the grading:

Description of Plant.—The plant consists of two large pumps placed on barges 110 by 30 feet, 6-foot hold, on the deck of which are the machinery and boilers. A cabin is erected above the boilers and machinery, which contains sleeping room for 30 men. The machinery of No. 1 consists of a double-acting duplex plunger pump—that is, two pumps which are so constructed that the plunger of one pump moves the steam valve of the other, and *vice versa*. On No. 3 the pumps work single. Each of these engines is compound. The 18-inch initial steam cylinders exhaust into an auxiliary steam cylinder of 36 inches diameter. Out of this the steam is exhausted into a condenser by an air-pump, which at the same time pumps water into the condenser. The water is heated by this condensed steam to a temperature of about 100°, and, passing from the condenser into a well, is used to supply the boiler. The stroke of the main pump varies according to the water pressure required, the maximum is 24 inches. The plungers are 16 inches in diameter. Besides these pumps, which are required for the grading proper, each of the graders has an engine for hoisting the boom-pipe and stages; also a steam capstan. The hoisting engine is located forward of the main pumps between the legs of the shears; the capstan is placed at the other end to facilitate the handling of the boat. There are three five-flue boilers on each grader 42 inches diameter and 22 feet long. On No. 1 the boilers are of steel, and on No. 3 of iron, both of 60,000 T. S. They were tested for a steam pressure of 125 pounds. They are supplemented by an upright auxiliary boiler for cleaning and pumping up main boilers. In front of the furnace is the coal-box, with storage room for 500 bushels of coal. The water to supply each of the main pumps is taken from a well in the bottom of the boat 3 by 3 feet, one on each side, through a 12-inch pipe. The bottom of the well is covered by a strainer made of three-eighths-inch flange iron. This strainer has 2,500 holes of three-eighths-inch diameter, which gives nearly 2½ times the area of the suction pipe. The water is discharged through two 12-inch pipes, one from each pump, into the main pipe, to which the boom-pipe is connected, the joints so arranged where the pipes come together as to allow the boom-pipe to have motion, both perpendicular and horizontal. The length of the boom-pipe is 65 feet, tapering from 12 inches to 8 inches, and consists of 4 flanged pieces, which are bolted together. These pieces of the boom-pipe are lapwelded tubes screwed in to cast-iron flanges and bolted through flange and screw end of tube. The whole is stiffened by two hog-chains, one below extending along the whole length, the upper one on top of the two smallest pieces to which is attached the hoisting rope. The hoisting rope is 1 inch-steel wire leading over a pulley on top of the shears, thence to the drum of the hoisting engine. The shears are pine timber, 54 feet long, 12 by 12 inches, the heels butting in iron shoes on deck in a line with the hoisting engine. They are slightly inclined forward and are held by two 1½-inch wire rope guys, which are fastened to the gunwales. The pumps have a capacity to discharge 2,000 gallons a minute, under a pump pressure of 160 pounds.

Method of operating.—The grader is placed in position with one end next the bank, and the stage and boom-pipe lowered so as to almost rest on the ground. When the bank is perpendicular a trench is first cut at the proper slope so as to give a face to begin grading. When a steam pressure of 80 pounds, giving an efficient water pressure in the pumps of 140 pounds, is obtained, the work of grading is begun. A piece of 2-inch gas-pipe, about 4 feet long and pointed at one end, is driven into the ground about 10 or 15 feet from the face, and a little above the middle of the slope. The upper end of this gas-pipe is allowed to remain from 10 to 12 inches above the ground; a piece of iron is fitted into the top of this pipe, to support the nozzle, with holes on each side, into which trunnions on the nozzle fit, so as to admit of motion in any direction. After the nozzle has been fastened in this swivel and the hose connected with the boom-pipe at one of the valves, which are placed at intervals along the pipe for this purpose, two men take hold of the nozzle by means of a lever, which is fastened to it by clamps, and the signal is given to turn on the water; 3 or 4 men are kept ready to lighten up the hose, so as to enable the nozzle-men to point the nozzle in any required direction. The stream issuing from the nozzle is directed against the bottom of the face to undermine it to a depth of from 6 to 12 inches, and in doing this is moved along the whole length of the slope. The earth that has caved through this undermining is then washed into the river. The quickest way to do this is to soak the whole of the loose material first and then direct the stream so as to carry this saturated material into the river, pushing it down by the force of the stream. In undermining, it is always best to commence at the bottom and move upward. If the bank is more than 14 feet high 2 nozzles can be worked with advantage. Where one nozzle is used 11 men are required, while for two, 3 additional men are needed. The force to run one grader requires 1 foreman, 2 engineers, 1 fireman, 1 greaser, 2 nozzle-men, and 4 laborers—total, 11 men. With 2 nozzles working, 15 men are required. A 1¼ or 1½ inch nozzle is then put very near the top of the slope, and undermines the upper one-third of the face, while the 2-inch nozzle does the same with the lower two-thirds, and washes all of the caved material into the river. After the bank has been caved and washed down as far as from 30 to 35 feet from the nozzle this is moved 10–15 feet again. In doing this the water is shut off from the hose, and is wasted through one of the other valves. The difference in the quality of the material that has to be undermined or cut into, the various positions in which the different strata are found underlying each other, height of bank, &c., requires, besides this general method employed, various modifications in special cases of managing the nozzle that can hardly be described, and only learned by experience. This is well demonstrated by the cost of grading.

While grader No. 1 was at Delta Point, opposite Vicksburg, in November and December of 1882, the cost for grading for the first two weeks was 9 cents, from November 20 to 30, 6 cents. In December No. 1 excavated 39,000 cubic yards, at an actual cost of 3½ cents. Grader No. 3 had in the mean time excavated at Mayersville Island 15,000 cubic yards, at a cost of 2⅔ cents, the bank consisting entirely of sand, while at Delta it was to a great extent intermixed with strata of hard clay, the different strata lying in unfavorable position for rapid work. In January, 1883, Nos. 1 and 3 together excavated on Mayersville Island 78,000 cubic yards, at a cost of 3⅓ cents, or, deducting all time lost through inclemency of the weather, &c., of 2.8 cents. The cost of grading in February cannot be as accurately calculated, as the grading did not amount to much, and was interrupted and delayed through stormy weather and the rising river. Work was stopped on the 7th of February.

Grading again began September 26. Serious delays have been caused by the bursting of the hose. Nearly one-half of the time in the first two weeks was lost on this account, making it necessary to constantly stop grading and change hose. The hose had been in use the previous season. Besides, all outside laborers and foremen were inexperienced, and after most of this trouble had been overcome, the rubber valves in the main pumps commenced to give out, and, as there were only few extra ones on hand, it was thought advisable not to work the pumps up to their full capacity. The work consequently progressed comparatively slowly. In September, only 3,260 cubic yards were excavated, the cost of which cannot be properly calculated. In October, in the first ten days, of ten working hours each, 11,395 cubic yards were excavated by No. 1. Since October 11 grader No. 1 has been worked both day and night; at night the electric light has been used, which had been put up in January last. A double crew was put on, changing every six hours, and working twenty out of twenty-four hours. Twenty-five thousand eight hundred cubic yards were thus excavated from October 11 to October 20. On the 20th orders were received to work three crews and to make no stoppage for meals. In the one hundred and fifty-two working hours from October 20 to 29, when work had to be temporarily stopped, 25,111 cubic yards were excavated, making a total of 62,306 cubic yards excavated in the month of October, at a cost of 3 cents per cubic yard. The slope made during the last month is smoother and more uniform than any ever made before, and requires very little or, in some places, no grading even by shovels to make it ready for revetment. This, I think, is of more importance than to do more excavating with a less smoothly worked slope. I have already mentioned that the usually required water pressure is 140 pounds for one nozzle, while for two nozzles the pressure is run up to 160 pounds. A greater pressure cannot be used very well, as it makes it difficult and dangerous for the nozzle-men, besides the liability of bursting hose. By daily observations made during the last month it is found that to excavate one cubic yard of earth it takes a small fraction less than one cubic yard of water under a pressure of 140 pounds, this water pressure being attained by a steam pressure of 80 pounds and a vacuum of 26½ inches. With a pressure of 80 pounds of steam it takes 3 pounds of coal per cubic yard of water thrown or earth excavated. In comparing this hydraulic grading of earth with hand work by use of shovels, I think I may safely assume that the moving by shovel would cost 30 cents per cubic yard. This makes a difference in favor of the hydraulic moving of 27 cents. Grader No. 1 has so far moved about 165,000 cubic yards, and caused a saving, therefore, of nearly $44,550, or over one and one-half times the original cost. I am confident that another month's constant running, with the past experience, new hose, new valves, &c., the cost per cubic yard can be greatly reduced.

Bank revetment.—Where revetment has been laid, a grillage of poles is first placed along the slope; on this grillage the brush is laid perpendicular to the direction of the current; another set of poles is laid on top of the brush over those underneath, to which they are fastened with wire to hold the brush in place. The poles are also fastened with wire to stakes driven in the slope, and the revetment covered with stone. On account of the scarcity of stone last season bags of sand were tried for the purpose of keeping the revetment in place, but they failed in accomplishing the desired result; they were easily torn, and the action of the current washed out the sand, rendering them useless for the object intended. The following tabulated statement, showing the amount of work accomplished by the bank-protection party, and its condition November 1, 1883, with an estimate of the labor, cost, and material required for the different kinds of work, has been furnished by Assistant Engineer W. M. Childs, who has had charge of this class of work from the beginning:

Statement of brush-work about pile-dikes from December 1, 1882, *to November* 1, 1883.

Location.	Dikes.	Foot-mat between piling.				Woven mat along piling.			Shore mat or revetment made and rocked.	Screens hung.		Wattling.	
		Made.		Sunk.		Made.	Sunk.	Width.					
		Lin. ft.	*Sq. ft.*	*Lin. ft.*	*Sq. ft.*	*Lin. ft.*	*Lin. ft.*	*Lin. ft.*	*Sq. ft.*	*Lin. ft.*	*Sq. ft.*	*Lin. ft.*	*Sq. ft.*
Duncansby	Duncansby bar protection					320	320	100		320	8,050		
Do	Main dike A					1,615	1,615	60	142,022	82	2,112	3,097	25,671
Do	No. 5	65	2,080	65	2,080								
Do	No. 6					1,675	1,675	180					
Do	No. 7	1,317	64,702	826	34,122								
Do	No. 8	2,810	91,149	1,650	55,024								
Mayersville	Main dike	700	17,500	1,000	25,000								
Baleshed	Main dike	4,305	207,615	3,239	165,185	8,335	6,741	60				1,708	10,586
Do	No. 1	933	39,132	933	39,132							995	7,449
Do	No. 2	1,192	94,027	810	61,175								
Do	No. 3	1,172	70,578	700	42,154								
Do	No. 4, of '82	717	15,774	717	15,774								
Do	No. 5, of '82	581	12,782	581	12,782								
Do	No. 5, of '83	965		1,090									
Do	No. 6	999		1,749									
Do	No. 7	1,125		1,125									
Do	No. 12	918	20,196	918	20,196								
Stack Island	Main dike	3,642	114,885	3,838	102,725								
Elton	Main dike	1,475	44,250	1,475	44,250		225	100					
Do	No. 2	950	26,600	950	26,600								
Do	No. 3	975	29,250	975	29,250								
	Totals	24,341		22,141		11,945	10,576		142,022	402	10,162	5,800	43,796

Statement of bank revetment from December 1, 1882, *to November* 1, 1883.

Description of work.	Location.	Mattress work for bank protection.						Remarks.
		Remaining in good condition November 1, 1883.			Washed away or bank caved back of mattress.			
		Length.	Width.	Area.	Length.	Width.	Area.	
		Feet.	*Feet.*	*Squares.*	*Feet.*	*Feet.*	*Squares.*	
Woven mattress	Protection dike at head of Duncansby tow-head				277	135	374	All the work shown here has been washed away by the caving bank of the tow-head. The mattresses are on the bottom and show up at places, but are useless for the purposes for which they were intended.
Do	Duncansby tow-head inside				240	135	324	
Do	do				267	135	360	
Do	do				430	100	430	
Do	Duncansby tow-head outside				288	100	288	
Do	Duncansby tow-head across head				282	96	271	
Do	do				321	50	160	
Do	Mayersville Island between Ranges 52 and 54				4,600	100	4,600	This work is in many places intact on the bottom, but the bank has caved back so as to render the building of a new mat necessary between old mattress and the present bank.
Do	Mayersville Island between Ranges 54 and 55				1,200	120	1,440	
Do	Mayersville Island 225 feet below Range 54				600	75	450	
Do	Mayersville Island between Range 54 and foot of island	5,210	186.8	9,784				
Totals		5,210		9,784	8,505		8,697	
Revetment	Duncansby tow-head inside				425	42	179	
Do	Mayersville Island at head	1,700	58.6	996				
Totals		1,700		996	425		179	

SUMMARY OF ABOVE STATEMENT.

	Feet.	Squares.
Linear feet of mattress in good condition, November 1, 1883	5,210	9,784
Linear feet of revetment in good condition, November 1, 1883	1,700	996
Totals	6,910	10,780
Mattress washed away by caving of tow-head, and from which the bank has caved back on Mayersville Island	8,505	8,697
Linear feet of revetment washed away on Duncansby tow-head	425	179
Total	8,930	8,876

From the above statement an estimate is made of the cost of protecting caving banks with a woven mattress 150 feet wide, the slope graded and covered with a brush revetment held in place with stone, as follows:

In this estimate a square = 100 square feet.

Labor cost for 100 linear feet:		
150 squares mattress, at $1.21		$181 50
40 squares grillage, at $1.61		64 40
Graded, at 55 cents		55 00
60 squares revetment, at $1.70		102 00
Sinking 190 squares mats, at 18 cents		34 20
Covering with rock 60 squares revetment, at 50 cents		30 00
		467 10
Add cost of—		
Material, 153.75 cords brush, at $1.75	$269 06	
Sinking mats, 72.2 yards stone, at $2	144 40	
Covering revetment, 30 yards stone, at $2	60 00	
12.5 cords poles, at $2	25 00	
127.2 pounds spikes, at 5 cents	6 36	
222½ pounds wire, at 7 cents	15 54	
1,000 pounds iron rod, at 5 cents	50 00	
Towing, estimated one-sixth of cost of tow-boat service	83 32	
		653 68
Total cost of 100 linear feet		1,120 78

Or, per linear foot, $11.21.

SUMMARY.

Work completed from December 1, 1882, *to November* 1, 1883, *and in good condition.*

Number linear feet pile dikes, 44,235.
Number linear feet woven foot mats, 11,945; squares of 100 square feet, 9,386.1.
Number linear feet grillage, 24,341; squares of 100 square feet, 9,586.2.
Number linear feet woven mattresses, 5,210; squares of 100 square feet, 9,734.
Number linear feet bank revetment, 2,645; squares of 100 square feet, 2,416.22.

SURVEYS, ETC.

After completing the survey and maps of the low-water survey of October, 1882, the party under Assistant Engineer Blunt made a hydrographic survey of the Choctaw Reach from △ Caulk's Point to △ Arkansas City, occupying them from November 16 to December 31, 1882, the party returning to Wilson's Point on the latter date.

During January, 1883, maps were made of the Choctaw Reach survey, of comparative soundings at Pilcher's Point, and soundings taken from foot of Island 93 to foot of Island 94; pile dikes were located, and the lines of regularized river marked by flags on range lines on Baleshed Bar. In February and March, soundings for comparison were taken in various parts of the reach near Duncansby and Baleshed Bars and Mayersville Island, maps of which were made and are on record. Caving banks were resurveyed, showing changes; new levees located from Duncansby to Homochitto, at Elleslie, and at Shorts, and a general preparation made in office and field for a high-water survey. A variety of map work was done. In April and May a high-water survey was made from Pilcher's Point to Range 100; contour and section maps made. Sections for comparison were sounded in the Duncansby and Baleshed chutes, and similar work done in June, July, and August.

Assistant W. T. Blunt resigned May 15, and was succeeded by Assistant Hart Vance, who took charge May 17. In September a complete low-water survey was made from Range 14 to Range 107, shore lines and bars resurveyed, and water surfaces determined for slope in various parts of the reach.

The survey was concluded in October, and maps made of same, and also in reduced scale for annual reports. This survey shows Duncansby, Mayersville, Baleshed, and Stack Island chutes closed at low water, and a channel of not less than 10 feet at 1.5 on the Lake Providence gauge through the reach from Ashton to Point Lookout.

The lowest gauge reading for the year was 4.45 (L. P. gauge), October 5, so that at the period of lowest water during this year there was a channel of not less than *fifteen feet* in that part of the river covered by the survey. The maps accompanying annual report show all dike and mat work constructed since the beginning of the work and standing October 31; also the sand-bars appearing at the time of the September survey, and the same bars as they would have appeared in December, 1881, before the construction work commenced, had the river been at the same stage the September, 1883, survey was made. The Louisiana shore line at Pilcher's Point has caved back 200 yards since low-water survey of 1882. The maps of comparative sections were taken from surveys of February, 1882, and September, 1883, and show nearly the total change in the channel since the beginning of dike construction, as but little was done previous to February, 1882. Regular ten-day-progress sketches of construction work were furnished up to July 1, except while the party was engaged on the Choctaw Reach. Since that date they have been made once a month. All soundings were located either by transit or sextant in regular surveys; shore lines and bars, by stadia lines checking upon triangulation stations. In September gauges reading the same as the Lake Providence gauge were set at Lake Providence and Baleshed dikes, Wilson's Point, and Sarah's Island, to determine slope. Of these, the ones at Baleshed, Lake Providence, and Wilson's Point have been read twice daily; a gauge has been maintained at the quarter-boat the entire year, readings being taken at 7 a. m. and 6 p. m.

	Feet.
Lowest gauge reading October 5, 1883	4.45
Highest gauge reading July 6, 1883	35.30
Oscillation of river	30.85

Summary of work done by the survey party.

	Choctaw Reach.	Lake Providence Reach.	Totals.
General surveys	1	2	3
Number of soundings	2,038	13,235	15,273
Ranges located	73		73
Shore lines located ... miles	25	25	50
Slope observations	10	16	26
Triangular stations built	36	17	53
Triangular stations located	30	12	42
Special surveys		13	13
Longitudinal soundings		148	148
Levels run ... miles		25	25
Maps made			57
Tracings			47

This party was under the charge of Assistant Engineer W. T. Blunt until May 13, 1883, and from that time until November 1, under that of Assistant Engineer Hart Vance. The above report of the work done, and the tracings accompanying this report, have been furnished by Assistant Engineer E. D. Thompson, who is at present in charge of the party.

Plant, &c.

The following is a list of boats and barges, &c., on reach November 1, 1883: 19 quarter-boats; 1 boat used as machine and repair shop; 1 tow-boat (Vidalia); 3 tow-boats (chartered); 1 steam-launch (Nellie); 1 snag-boat (O. G. Wagner); 2 hydraulic graders; 1 derrick-boat; 9 large mattress-boats; 4 small mattress-boats; 21 pile-drivers; 5 coal-barges (decked); 46 decked barges (brush and stone); 1 catamaran; 9 coal-barges (open); 1 coal-boat; 10 small flats for pile-driving; 60 skiffs; 195 pièces in all.

Five of these quarter-boats were built here on the hulls of coal-barges, one coal-barge decked and one cut down to serve as a mooring-barge. The rakes and sides of 35 barges and 5 pile-drivers have been caulked, changes and repairs made to pile-drivers, and the general repairs incident to so large amount of floating property, kept up. The plant is generally in good condition except some of the coal-boats, which are worthless. The bottoms of some of the barges will need caulking next season.

The average cost of subsisting the employés for each days' labor secured, has been 42.2 cents, including cost of ice during the warm months. The number of days' service obtained each month has been as follows:

December, 1882	14,077	April, 1883	8,565	August, 1883	14,547
January, 1883	19,008	May, 1883	9,721	September, 1883	12,234
February, 1883	10,826	June, 1883	13,017	October, 1883	14,841
March, 1883	6,785	July, 1883	13,296		

GENERAL REMARKS.

The general effect of the work done has been such as to give a better channel through the crossings which heretofore at low water have been shoal. At the lowest water this year, 4.45 feet on the Lake Providence gauge, there was a good 15-foot steamboat channel through the entire length of the reach, as shown by the October survey. Difficulties have been encountered in pushing the work during the months of August, September, and October, principally on account of lack of labor and sickness among the men, caused by the malaria incident to this climate. Neither sufficient material could be obtained from the the contractors, nor labor to have used it had material been supplied. During these months but little progress can be made, reducing the time when work can be done, so as to take advantage of the low-water season, to, say about three months from the middle of October to the middle of January. White laborers in August, September, and until about the middle of October get sick soon after their arrival and become inefficient; the colored labor prefer cotton-picking and leave the work about this time. The labor question during these months is a serious one, and together with the difficulty of obtaining sufficient material, brush and stone, on account of its bulk and the distance it has to be transported, will always be serious drawbacks to the rapid prosecution of the work when the condition of the river is the most favorable to work to the best advantage, which is generally at this season of the year. To the assistant engineers in charge of the construction parties and those engaged under them credit is due for the interest displayed, the ability shown in pushing their work, often under unfavorable conditions, and to their untiring efforts in this direction, in a great measure, is due whatever success has been attained. The assistant engineers in charge of the surveys have also kept their work well up, as evidenced by the surveys made and maps furnished. To all the employés I feel under obligations for their hearty support in carrying on the work.

Very respectfully,

ARTHUR HIDER,
Assistant Engineer in Charge.

Capt. W. L. MARSHALL,
Corps of Engineers, U. S. A.

L 2.

REPORT OF J. E. TURTLE, ASSISTANT ENGINEER, UPON OPERATIONS AT PILCHER'S POINT.

PILCHER'S POINT, LA., *November* 3, 1883.

CAPTAIN: In compliance with your orders of September 21, I have the honor to submit herewith the following report of operations of the improvement of the Mississippi River at Pilcher's Point, from May 17 to October 31, 1883:

This work was originally assigned to Assistant-Engineer J. E. Willard, who, under your instructions, reached Pilcher's Point on May 17, and with a small labor force, four carpenters and blacksmith, commenced the erection of such buildings and making such preparations as were necessary for the beginning and completion of this work.

The buildings erected are as follows: 1 office and sleeping apartment for assistant engineer and clerks, 1 kitchen and dining-room, 1 commissary, 1 store-room, 1 stable, 1 blacksmith shop.

Besides the above carpenter work, there was constructed in the early part of the season one mattress head, 163 by 20 feet, which will be hereafter described, and ventilators were put on three quarter-boats. While the above work was in progress the labor force was employed in cutting timber from caving bank, and cutting poles for mattress.

Owing to the scarcity of labor, the force, which consisted of 20 men, could not be materially increased, and it was August 13 when the necessary preparations were made for the construction of mattress. On that date a mat was begun. As there was no tow-boat at this time secured for this work, and as the sickly season was approaching, with a probable shortage of material on part of the contractors, on August 16 you issued orders that there should be no further steps taken to increase the force.

Mattress construction was continued without any material change in the force until September 15, when orders were received to increase the force as rapidly as possible.

Assistant Engineer J. E. Willard resigned on August 31, and I was placed in charge, having reported for duty on August 27.

From September 15 every available step was taken to increase the force, but owing to the continued warm weather there was a marked scarcity of labor until the early part of October. On October 3 a brush party was started on Sarah's Island, opposite Ashton, with a force of thirty-one laborers; which force was increased as much as could be done without any detriment to the construction of mattress.

The brush party is at present making good progress, and, with the addition of the tram-cars now ordered, will supply the three mattress-boats at this place. The shortest haul of the brush is one mile, and I think there can be secured from Sarah's Island 8,000 cords of choice brush.

DESCRIPTION OF WORK.

The mattresses are constructed in the usual way, upon ways built on mattress-barges, launches being made when the ways are full, by means of lines and captains; the material employed being poles, longitudinal and transverse, willow brush, spikes, wire, and iron rods which run longitudinally through the mattress. These rods are fastened together by means of lap-links, and fastened to the weaving-poles by means of staples; at every hundred feet they are fastened to the mat by wire, the connection of the rods being continuous.

The brush is hauled by mules, on cars properly adapted for the purpose. These cars are four feet gauge, and run on a track made of wooden rails, iron rails being employed in the curves.

On October 16, the first mat at this place was successfully sunk, and two others commenced; one at the head of caving bank, the other overlapping the one sunk. The location of these mats is shown on tracings accompanying this report. At this date there are under construction two mattresses, one 150 feet in width, the other 182 feet in width. Each of these is making good progress, and is being pushed as rapidly as possible. The amount of mat made now per day is nearly double that made ten days ago, without any change in the force employed. This is due to the fact that when laborers come here the work is entirely new to them.

There is in readiness a third mattress barge, which will be put in use as soon as the supply of brush can be increased. One of the mattress boats is supplied with poles by hired labor, the other is furnished by a contractor.

The mattress head employed and intended to be used instead of a mooring-barge proved a perfect success; a drawing of this mattress head is submitted with this report. This mattress head consists of two chords, 20 feet apart, with a series of cross and diagonal bracing, and a hog-chain, as shown in drawing.

The up-stream chord is 12 inches in width by 30 inches in depth; the lower one 12 inches in width by 19 inches in depth; these chords are one hundred and sixty-three feet in length, and have a camber of 6 inches; they are constructed of pine plank. During the construction of the mattress it is by lines anchored to the mattress head. During the sinking, the mattress head is sunk with the mat, and by means of a lever and trips the mattress head is released from the mat and again used. The method employed in sinking and releasing the mattress head is as follows: The mat to which it was attached was 1,228 feet in length by 152 feet in width. The sinking of the mat was commenced near the center and the mat loaded with stone both ways; in this way the entire mat was gone over and sunk to a depth varying from 10 feet to 35 feet.

Two barges were then lashed together side by side, and about 8 feet apart, and placed about 50 feet from mattress head; and this portion of the mat loaded for the second time. These barges were by means of lines pulled up stream and toward the mattress head, the stone being thrown from each barge on the up and down stream sides. This loading caused the mattress head to sink rapidly. Previous to this second loading of the mattress, the depth of water at outer end of mattress head was carefully taken, a sounding line was made fast to lower chord of mattress head and held by a man in a skiff, the object of this was to know how rapidly the mattress head was sinking. When it had sunk to $\frac{3}{4}$ of the entire depth, ten men who were ready to haul on a line made fast to ring at upper end of lever were ordered to pull. The mattress head was at once released, and the head of the mat being relieved of its buoyancy sank rapidly to the bottom.

The snag-boat Wagner reported for duty on September 21, and has been employed in pulling snags from this bend; she was employed 7 days pulling piles from dike at head of Duncansby chute, and has lost 5½ days in making repairs.

Towboat Pearl reported for duty September 22, and has, with the exception of a few days, been constantly employed.

SUMMARY OF WORK DONE.

Built: One office and sleeping-room, 28 by 22 feet; 1 kitchen and dining-room, 30 by 18 feet; 1 commissary, 32 by 20 feet; 1 warehouse, 32 by 20 feet; 1 stable, 20 by 15 feet; 1 blacksmith shop, 14 by 16 feet; 1 mattress head.

Ventilators placed on 3 quarter-boats.

Roofs of 4 quarter-boats painted.

Mattress constructed: 928 by 152 feet, 300 by 235 feet, 610 by 150 feet, 585 by 182 feet.

Mattress sunk: 928 by 152 feet, 300 by 235 feet.

Snags pulled: 184; piles pulled, 122; cords of brush cut, 2.059; cords of brush hauled and loaded on barges, 1,109; cords of poles cut, 94.

Feet of track laid, 8,324; feet of track corduroyed, 1,872.

Timber has been cleared from the bank below Pilcher's Point for a distance of 5,248 feet and 400 feet in width, and above Pilcher's Point for a distance of 1,480 by 100 feet in width.

Respectfully submitted.

J. E. TURTLE,
U. S. Asst. Engineer.

Capt. L. W. S. MARSHALL,
Corps of Engineers, U. S. A.

L 3.

REPORT OF H. ST. L. COPPÉE, ASSISTANT ENGINEER, UPON IMPROVEMENT OF VICKSBURG HARBOR.

OCTOBER 21, 1883.

CAPTAIN: I have the honor to submit herewith a report on the improvement of Vicksburg Harbor, dating from December 1, 1882, to October 10, 1883, accompanied by maps, profiles, tables, &c.

Very respectfully, yours,

H. ST. L. COPPÉE,
Assistant Engineer.

Capt. W. L. MARSHALL,
Corps of Engineers, U. S. A.

REPORT ON IMPROVEMENT OF VICKSBURG HARBOR, FROM DECEMBER 1, 1882, TO OCTOBER 10, 1883.

I have divided the following report, in accordance with the progress of the work, into five parts, viz: The protection of Delta Point, La.; dredging in Vicksburg Harbor proper; survey of harbor and Mississippi River in the vicinity; results obtained by comparison of surveys from 1877 to 1883; and tables.

The protection of Delta Point, with a view to stopping the caving of its banks and keeping the channel of the river as near its old bed as possible, was commenced in 1878 and carried on in succeeding years up to the season of 1882, under the direction of Maj. W. H. H. Benyaurd. During this time a spur-dike was constructed with brush and stone, two screen-dikes built and anchored in the current, and 144 mattresses sunk (as shown on maps), the last mattress sunk in 1881, occupying a position just below the spur-dike. In October, 1882, I commenced the further revetment of the point, under your directions. In compliance with an order received from you November 24, 1882, I forwarded to your office a report, accompanied by maps, giving the positions and extent of the work accomplished at Delta, up to December 1 of that year; also a description of the methods adopted and under way, for protecting the banks against the action of the current. These methods were not changed, but the work carried on in the same manner to its completion, with the one exception, that the plan of driving piles through the upper edge of the mattress was abandoned, so that no obstructions would be offered to the sinking of mats on the upper graded bank during high water, in place of revetment, which it would be impossible to build.

December 1, 1882, the condition of the work was as follows:

Grade of upper bank, finished to a slope of about 2½ to 1	linear feet	1,476
Grade partly finished	do	300
Poles or frame-work on upper bank	do	305
Upper bank revetted with brush	do	800
Upper bank revetted with brush and covered with stone	square yards	2,929
Foot-mats built, 35 feet wide	linear feet	400
Foot-mats built and sunk, 35 feet wide	do	140
Mattresses constructed, 144 feet wide	do	1,260
Mattresses constructed and sunk, 144 feet wide	do	894
Piles driven through edge of mattresses		54

At this time the water was standing at 13.7 feet on the gauge, and all other conditions favorable for pushing the work. About 440 men were employed; 90 at the brush camps, 10 at the pole camp, 322 constructing mattresses, revetting the upper bank, grading with shovels, &c., and 18 on the hydraulic grader. This force was as great as we could possibly keep in work, with the plant in use. The work was carried on, the force employed varying, but approximating the above number, until February 10, 1883, when, owing to the high stage of water and lack of funds, it was abandoned. January 5, 1883, the hydraulic grader No. 1, having cut the banks to the required slope as far down the river as it would be possible to mattress during the season, returned to Wilson's Point, having during its stay at Delta, from November 7 to January 5, graded 3,500 linear feet of bank. During the month of December it moved 38,790 cubic yards of earth. Operations during the month of February were carried on with much difficulty, owing to the high stage of water, swift current and constant annoyance occasioned by the drift in the river; at one time the pressure from the latter on our mattress barge, was so great as to break the lines connecting it with the floating mattress, and carry it down the river nearly a mile. The mattresses were also sunk with trouble, the drift having accumulated under them to such an extent during their construction. During the progress of the work, *i. e.*, from October 10, 1882—to February 10, 1883—no portion of the mattresses, foot-mats, or bank revetment was lost. The work accomplished during this time was as follows:

Mattresses constructed and sunk:

Mattress No. 1	feet	130×184
Mattress No. 2	do	140 365
Mattress No. 3	do	144 358
Mattress No. 4	do	144 280
Mattress No. 5	do	144 87
Mattress No. 6	do	144 300
Mattress No. 7	do	144 285
Mattress No. 8	do	144 400
Mattress No. 9	do	144 460
Mattress No. 10	do	144 408
Mattress No. 11	do	136 475
Mattress No. 12	do	144 80
Mattress No. 13	do	80 745
Mattress No. 14	do	140 45
Mattress No. 15	do	140 40
Mattress No. 16	do	150 40

Foot-mats constructed and sunk, about 35 feet wide	linear feet	830
Bank revetted and covered with stone	do	3,500
Piles driven		96
Bank graded, grader No. 1, 3,500 feet Bank graded, shovels, 1,000 feet	linear feet	4,500
Unfinished work:		
Revetted, but not stoned	feet	400×25
Pole or frame work finished	do	112 18

The position and extent of the work is shown in plan, as on accompanying plate. The cost of protecting the bank at Delta—*i. e.*, the cost for labor and materials, not including camp expenses, purchasing tools, rope, general outfit, towing, superintendence, assistants, clerks, &c.—was as follows:

Cost of constructing and sinking 100 *feet of mattress* 144 *feet wide.*

Brush, 60 cords, at $2.53	$151 80
Poles, 166, at 32 cents	53 12
Wire No. 12, 170 pounds, at 5 cents	8 50
Spikes, 6-inch, 50 pounds, at 5 cents	2 50
Nails, 40d, 30 pounds, at 4 cents	1 20
Rock, 60 cubic yards, at $1.90	114 00
50 men, 1 day, at $1.65 (including subsistence)	82 50
1 foreman, at $2.15 (including subsistence)	2 15
1 master laborer, $1.90 (including subsistence)	1 90
Total	417 60
Cost per linear foot of mats	4 17

Cost of 100 feet of upper bank revetment, 75 feet wide.

Brush, 30 cords, at $2.53	$75 90
Poles, 150, at 32 cents	48 00
Wire, No. 12, 375 pounds, at 5 cents	18 75
Spikes, 6 inches, 60 pounds, at 5 cents	3 00
Rock, 150 cubic yards, $1.90	285 00
Fifty men (1 day), $1.65 (including subsistence)	82 50
One foreman (1 day), $2.15 (including subsistence)	2 15
One master laborer (1 day), $1.90 (including subsistence)	1 90
Total	517 20

Cost per linear foot of revetment, $5.17.

The excessive cost of willow brush and poles used in the above estimate was due to the long haul necessary in order to obtain them of the desired size and quality and in sufficient quantities, and also to the soft condition of the bar from which they were secured.

Cost of grading 100 feet of bank 75 feet wide (average 30 feet high above water surface: Average excavation grader No. 1 in bank; 100 feet by 75 feet = 3,000 cubic yards, at 5 cents, $150.

Grading with shovels:

Seventy men (2 days), $1.65 (including subsistence)	$231 00
One foreman (2 days), $2.15 (including subsistence)	4 30
One master laborer (2 days), $1.90 (including subsistence)	3 80
Small grader and boxer, $7.00 per day (2 days)	14 00
Total	403 10

Cost of grading per linear foot, $4.03.

RECAPITULATION.

Cost of mats per linear foot	$4.17
Cost of revetment per linear foot	5.17
Cost of grading per linear foot	4.05
Cost of protecting bank per linear foot	13.37

February 10 the water stood 32.7 feet on the Vicksburg gauge, and continued at a high stage, as shown in the table of gauge readings, appended, until early in July. During this entire time a current of 5.6 feet per second, swept by the revetted bank, making further operations there impracticable, even had the work been incomplete and funds available. In the latter part of February you directed me to have five of the coal barges used during the season decked, for the purpose of carrying brush on the Lake Providence reach; this was accomplished, and they were sent early in March with the balance of the Delta outfit to Wilson's Point.

DREDGING IN VICKSBURG HARBOR.

The first part of the original plan recommended by the Board of Engineers (January, 1878) for the improvement of the harbor, *i. e.*, the protection of Delta Point, having been accomplished, the second part, or dredging a canal and basin in front of the city, was commenced April 5, 1883. November 30, 1882, the contract for dredging was awarded to Mr Rittenhouse Moore, of Mobile, the understanding being that in accordance with the specifications issued by you, he would commence work before February 1, 1883, and finish to the full extent of the available funds ($100,000) by October 1 of the same year. April 2, or two months after the time specified in the contract, the dredge Thos. H. Herndon was towed into the harbor; and April 5 commenced excavating; your instructions being to dig a basin 1,700 feet long by 320 feet wide, down to a horizontal plane passing through the zero of the gauge, thence to the same plane, a canal into the lake 150 feet wide by approximately 2,500 feet long (the position of canal and basin is shown on accompanying plate, XI), thence to move the dredge to the southwest entrance to the lake, and cut a channel through the bar forming there, of sufficient width and depth to allow boats to enter with a view to giving Vicksburg a temporary harbor during low water. The dredge was what is known asa crab or clam-shell dredge, capable of excavating, when well handled, on an average 4,000 cubic yards in twenty-four hours.

Up to April 10 work was carried on in the day-time only, but from that day until its abandonment on account of low water the dredge worked twenty-four hours each day, with the exception of Sundays, which were used for repairs to machinery. Two inspectors were employed by the Government to measure the amount of material excavated and placed in scows, each inspector remaining on the dredge twelve hours, thus dividing the day into two watches, as was also done by the crew employed by the contractor. Two scows were used to convey the material excavated to the point designated by the inspector. The capacity of the scows were respectively 116 and 266 cubic yards. The material was dumped in the low ground in the willow ridge opposite the compress (as shown on map), the haul or tow being about one mile, round trip, from the center of the basin. At first it was impossible to dredge to the desired plane (zero), as the guide or bucket-poles were not of a sufficient length to allow of the bucket reaching that depth, thus making it necessary to go over a portion of the proposed basin twice. It will be noticed by a glance at the gauge table that during the early stages of the work, nearly two months, the water was above the forty-foot mark; the dredging was necessarily slower and performed with greater difficulty than afterwards, when the river fell to a lower level. During the progress of the work there were numerous break-downs and delays, in many instances caused by bad management on the part of those representing the contractor. At times the force employed on the dredge was not sufficient to do the work properly. There were also some delays caused by the careless handling of boats that frequented the harbor, running over the guide stakes, lights, &c. This, however, was soon remedied by cautioning the pilots, it being to their interest to help rather than to retard the work. The dredging was at first confined to the basin, the material being taken out in cuts 40 feet wide, but not to the zero, as stated above, because of the shortness of the bucket-poles. Six parallel cuts were taken out the entire length of the basin, commencing at the western edge and working eastward to a plane about 5 feet above zero; thence, May 26, the dredge was moved to its eastern edge, and the water being sufficiently low commenced excavating to the zero. Four cuts were made working westward with the exception of a small ridge in front of and close to the elevator, which it was impossible to dig with the bucket in use. As the contractor claimed that this material was rock, I had borings made and found it to be as I anticipated, simply a hard, compact deposit.

The contractor was requested to send us a bucket capable of removing this, but did not comply with the request. July 18 the condition of the work was as follows (all the operations having been confined to the basin):

Four cuts or 160 feet from western edge excavated to + 5 feet. Four cuts or 160 feet from eastern edge excavated to zero, leaving 160 feet to be re-dredged in order to finish the basin to the required depth. There was practically no more work done in the basin. As the water at this time (July 18) had fallen to 38 feet on the gauge and was going down rapidly, you thought it expedient before finishing the basin to make a couple of cuts (a canal 80 feet wide to zero) to deep water in the lake, in order, if possible to prevent the necessity of moving the wharf boat and general river business to the lower landing. The dredge was therefore placed in the temporary canal, and worked there until August 2, when you ordered her moved to the southwest entrance to the lake. The lower entrance to the landing was at that time closed, and the upper or southwestern shoaling rapidly. The temporary canal was then in the following condition: One cut 40 feet by 2,500 feet excavated to zero, and a portion of a second 1,000 feet to the same plane. August 3, dredging commenced at a point on King's Bar, marked on the map West Pass, in twelve feet of water (the gauge reading 31.5 feet) and carried on up to the 24th. The material to be moved was of such a consistency (compact sand) that the soft-bottom bucket had to be abandoned, and one shipped by the contractor from Mobile used in its place. This worked to much better advantage, but was not a success. Numerous expedients were resorted to, but the plan of making a passage through the bar had finally to be abandoned and the dredge towed back to the second cut in the temporary canal. The accompanying map and profiles show the position and dimensions of the excavation at West Pass; its present condition is not all due to the dredging, but in great part to the scouring force of the current running from the lake into the river at that point The probability is that a rising river will fill this up again in a short time. From August 24 until September 18 the dredger worked in the temporary canal. At the latter date the gauge-reading was 7.4 feet, the dredge drawing 7.5 feet. As your orders were not to excavate below the zero plane, it was impossible to continue until the river should rise. The dredge was therefore removed to deep water in the lake, and as the river has continued to fall steadily, has remained there to date. Should the contractor wish to remove his outfit, the time for finishing the contract (Sept. 30) having expired, it will be impossible, all access to the main river being closed. During the progress of the work, a record of the material dredged was kept, giving the excavation per scow, per watch, day, &c., the causes of delay, and general log.

Table No. 10 gives the amount of material excavated each month, that taken from the basin, temporary canal, and West Pass, and totals. The total amount, 350,035 cubic yards, at 12.1 cents, $42,354.23, minus 10 per cent., $38,118.81, has been paid the contractor in monthly estimates. The condition of that portion of the lake where the excavation was made at the present time, to which I will refer in the results obtained by comparison of surveys, will show a decided filling or sliding in from the sides, giving a very poor idea of the amount of material originally dredged. There was also a deposit taking place during the entire time of dredging, as shown on the profiles, Plates XII and XIII.

SURVEY.

Early in September, in accordance with instructions to make a thorough survey of the harbor and Mississippi River in the vicinity, for the purpose of comparing the data thus obtained with the surveys of previous years, with a view to ascertaining the probable additional cost of dredging, should it be deemed expedient, and noting the changes that had taken place in the main river, I put a party into the field and obtained all the desired information by the 10th instant. The work in the inner harbor was pursued with some difficulty, being not only expensive but dangerous, the mud-bar in front of the city being in such a condition as to necessitate the laying of plank in order to obtain the elevation of the ground sounded the year before. The laborers employed in placing the plank ways were numerous times immersed up to their armpits, and but for the boards to which they clung would have disappeared entirely. This extremely soft deposit extended the entire length of the proposed permanent canal and basin, with the exception of a small strip of bar at section No. 1; the ground there, being much higher, was hardened by the sun, but one foot below the surface was very soft, as I ascertained by attempting to drive my horse over it.

The survey consisted in remeasuring and either leveling over or sounding the sections sounded in 1881 and 1882 in the inner harbor, twenty-three in number, running a line of levels from Ryan's lower saw-mill to a point on King's Bar opposite the Delta wharf-boat, obtaining the low-water line of King's Bar, the middle-ground bar, the bar above Delta, and the bar just below the revetted portion of the Delta Point bank, sounding twelve sections in the upper lake and fifteen sections in the main river. A meander line was run up to King's Point. Levels were also carried from the gauge at Kleinston to the gauge in the lake, the difference in elevation of the water in the river and lake obtained, cross-sections made of West Pass, and cross-sections of the excavated basin obtained every 100 feet, giving the slopes the sides had assumed. Posts were planted at the end of each section in the inner harbor for future use. The soundings were made in every instance as nearly as possible on sections used in previous years, in order to better compare results. The levels and soundings are referred to the zero of the gauge at Kleinston, no deduction being made in the case of soundings in the main river for slope, but simply referring them to the datum by subtracting the reading of the gauge at the time of sounding from the depth obtained.

RESULTS.

The results of this survey, and those made in the past, I have collected and arranged in the form of tables, which will explain themselves, leaving but little to be added. The data from which the changes during 1877, 1878, 1879, and 1880 were obtained were very meager, and in most instances but approximate; but will serve to show the general conditions which existed during those years, and the change which has taken place in the inner harbor since the time of the cut-off in 1876; a gradual filling has taken place which will continue until the lake is free from all access to the muddy water of the river, unless some means are adopted to cut off the current that flows around De Soto Island during high water. This current has existed since 1877 to a greater or less extent, having a velocity in that year of nearly one-fourth mile per hour. In 1882 it was hardly perceptible, float observations made in July of that year showing practically no velocity; but during the last high water it traveled from Ryan's mill to the compress at the rate of one-half mile per hour, gradually becoming slower as it reached the northern end of the island. This has caused a more rapid filling of the area than has taken place for years.

Glass Bayou, which enters the lake at the northern boundary of the city, has also been the cause of considerable filling, bringing during every heavy rain a great quantity of mud from the adjacent hills. The changes that have taken place in the main river during the last high water, as shown on the accompanying map, are to a great extent a repetition of what occurred the year before. The bar above Delta has moved down stream 600 feet; some caving has taken place at King's Point. The King's Point Bar has been split, the sand taken from its former crest being deposited in the form of a middle ground, outside of its old position and extending further down the river, closing more effectually the upper entrance to the lake, and threatening the permanency of the Kleinston landing. The bank has caved to some extent at Kleinston, and at present there is a strong eddy current there, the water running rapidly up-stream, along the Kleinston front. The bar below the revetted portion of Delta Point, has moved out at its upper end 100 feet, and 1,000 feet below, 200 feet. I made a personal examination of the revetment at Delta Point and found the following changes: The spur dike, built in 1879, has been swept away, carrying with it 260 linear feet of revetment; also at a point (marked on drawing of Delta Point "*Mud flat*") where no revetment was placed, there has been some caving. To protect the bank at and below the old dike, and at this mud flat, to insure the permanency of the work already done, it will be necessary to put down 500 linear feet of mattress The changes in the inner harbor are shown on the profiles, and in tables appended.

ESTIMATES FOR DREDGING.

First estimate, July, 1878	$80,000 00
Second estimate, July, 1880, to 15 foot plane, canal, 250 by 4,800; basin, 600′ by 1,800=2,235,555 cubic yards, at 15 cents	335,333 25
Third estimate, 1882, slopes 1¼ to 1, canal and basin same as in second estimate=2,315,195 cubic yards, at 15 cents	347,279 25
Fourth estimate, May, 1883, canal and basin, as in map, including temporary canal to —8 foot plane, slopes 5 to 1, adding 40 per cent. for expansion of material measured in scows	389,980 36
Fifth estimate, October, 1883, slopes 8 to 1 on one side and natural slope of old bank 3 to 1 on other; permanent canal, as shown in map, excavated to —8 plane=3,789,632.7 cubic yards+40 per cent.=5,305,485.7, at 15 cents	795,822 85
Material taken from the basin during the year, 244,456 cubic yards, at $12\frac{1}{10}$ cents	29,579 07
Total amount to be spent in order to finish permanent canal and basin, not allowing for fill during the progress of the work	766,243 68

Should the fill in the harbor be as great during the next high water, this estimate will have to be increased over $300,000, making the total cost, approximately, $1,000,000. The slopes assumed by the dredged portion of the lake are shown on the profiles.

TABLE No. 1.

Date.	Gauge.	Date.	Gauge.	Date.	Gauge.	Date.	Gauge.	Date.	Gauge.
1882.		1883.		1883.		1883.		1883.	
Dec. 1 ...	13.70	Jan. 1 ...	11.90	Feb. 1 ...	24.70	Mar. 4 ..	42.70	Apr. 4 ...	43.90
Dec. 2 ...	13.50	Jan. 2 ...	12.80	Feb. 2 ...	26.60	Mar. 5 ...	42.80	Apr. 5 ...	43.80
Dec. 3 ...	13.30	Jan. 3 ...	13.75	Feb. 3 ...	28.30	Mar. 6 ...	42.90	Apr. 6 ..	43.70
Dec. 4 ...	13.00	Jan. 4 ...	14.70	Feb. 4 ...	29.80	Mar. 7 ...	43.05	Apr. 7 ...	43.95
Dec. 5 ...	12.80	Jan. 5 ...	15.50	Feb. 5 ...	30.70	Mar. 8 ...	43.10	Apr. 8 ...	43.85
Dec. 6 ...	12.60	Jan. 6 ...	16.40	Feb. 6 ...	31.40	Mar. 9 ...	43.10	Apr. 9 ...	43.80
Dec. 7 ...	12.30	Jan. 7 ...	17.00	Feb. 7 ...	31.90	Mar. 10 ...	43.15	Apr. 10 ...	43.75
Dec. 8 ...	12.00	Jan. 8 ...	17.30	Feb. 8 ...	32.10	Mar. 11 ...	43.20	Apr. 11 ...	43.70
Dec. 9 ...	11.75	Jan. 9 ...	17.30	Feb. 9 ...	32.40	Mar. 12 ...	43.20	Apr. 12 ...	43.60
Dec. 10 ...	11.65	Jan. 10 . .	17.50	Feb. 10 ...	32.70	Mar. 13 ...	43.25	Apr. 13 ...	43.60
Dec. 11 ...	11.60	Jan. 11 ...	17.55	Feb. 11 ...	32.90	Mar. 14 ...	43.25	Apr. 14 ...	43.60
Dec. 12 ...	11.55	Jan. 12 ...	17.40	Feb. 12 ...	33.45	Mar. 15 ...	43.30	Apr. 15 ...	43.55
Dec. 13 ...	11.50	Jan. 13 ...	17.30	Feb. 13 ...	34.10	Mar. 16 ...	43.25	Apr. 16 ...	43.55
Dec. 14 ...	11.40	Jan. 14 ...	17.50	Feb. 14 ...	34.90	Mar. 17 ...	43.20	Apr. 17 ...	43.30
Dec. 15 ...	11.20	Jan. 15 ...	17.20	Feb. 15 ...	35.80	Mar. 18 ...	43.20	Apr. 18 ...	43.30
Dec. 16 ..	10.90	Jan. 16 ...	16.80	Feb. 16 ...	36.70	Mar. 19 ...	43.20	Apr. 19 ...	43.20
Dec. 17 ...	10.50	Jan. 17 ...	16.40	Feb. 17 ...	37.70	Mar. 20 ...	43.15	Apr. 20 ...	43.10
Dec. 18 ...	9.90	Jan. 18 ...	16.10	Feb. 18 ...	38.40	Mar. 21 ...	43.05	Apr. 21 ..	43.00
Dec. 19 ...	9.50	Jan. 19 ...	16.00	Feb. 19 ...	38.95	Mar. 22 ...	43.00	Apr. 22 ...	43.00
Dec. 20 ...	9.30	Jan. 20 ...	15.90	Feb. 20 ...	39.60	Mar. 23 ...	42.95	Apr. 23 ...	42.11
Dec. 21 ...	9.15	Jan. 21 ...	15.90	Feb. 21 ...	40.35	Mar. 24 ...	42.80	Apr. 24 ...	42.10
Dec. 22 ...	8.80	Jan. 22 ...	15.90	Feb. 22 ...	40.60	Mar. 25 ...	42.85	Apr. 25 ...	42.90
Dec. 23 ...	8.45	Jan. 23 ...	15.90	Feb. 23 ...	41.05	Mar. 26 ...	42.80	Apr. 26 ...	42.80
Dec. 24 ...	8.00	Jan. 24 ...	16.00	Feb. 24 ...	41.55	Mar. 27 ...	42.70	Apr. 27 ..	42.70
Dec. 25 ...	7.80	Jan. 25 ...	16.30	Feb. 25 ...	41.85	Mar. 28 ...	42.80	Apr. 28 ...	42.60
Dec. 26 ..	7.70	Jan. 26 ...	16.90	Feb. 26 ...	42.05	Mar. 29 ...	43.00	Apr. 29 ..	42.50
Dec. 27 ...	8.00	Jan. 27 ...	17.50	Feb. 27 ...	42.20	Mar. 30 ...	43.30	Apr. 30 ...	42.40
Dec. 28 ...	8.55	Jan. 28 ...	18.40	Feb. 28 ..	42.25	Mar. 31 ...	43.60	May 1 ..	42.30
Dec. 29 ...	9.30	Jan. 29 ...	19.40	Mar. 1 ...	42.35	Apr. 1 ...	43.80	May 2 ...	42.20
Dec. 30 ...	10.00	Jan. 30 ...	20.70	Mar. 2 ...	42.55	Apr. 2 ...	43.90	May 3 ...	42.10
Dec. 31 ...	10.90	Jan. 31 ...	22.70	Mar. 3 ...	42.65	Apr. 3 ..	43.90	May 4 ...	42.00

TABLE No. 1—Continued.

Date.	Gauge.	Date.	Gauge.	Date.	Gauge.	Date.	Gauge.	Date.	Gauge.
1883.		1883.		1883.		1883.		1883.	
May 5...	41.11	June 6 ..	38.80	July 8 ..	39.70	Aug. 9...	22.10	Sept. 10...	9.20
May 6...	41.11	June 7 ..	38.10	July 9 ..	39.70	Aug. 10...	23.00	Sept. 11...	8.90
May 7...	41.10	June 8 ..	39.90	July 10 ..	39.70	Aug. 11...	23.10	Sept. 12...	8.40
May 8...	41.90	June 9 ..	39.00	July 11 ..	39.70	Aug. 12...	23.30	Sept. 13...	8.00
May 9...	41.80	June 10 ..	39.10	July 12 ..	39.70	Aug. 13...	23.10	Sept. 14...	7.80
May 10 ..	41.90	June 11 ..	39.10	July 13 ..	39.60	Aug. 14...	23.00	Sept. 15...	7.40
May 11...	41.80	June 12 ..	39.10	July 14 ..	39.40	Aug. 15...	22.10	Sept. 16...	7.20
May 12...	41.80	June 13 ..	39.10	July 15 ..	39.20	Aug. 16...	22.10	Sept. 17...	6.10
May 13...	41.70	June 14 ..	39.10	July 16 ..	38.10	Aug. 17...	22.40	Sept. 18...	6.60
May 14...	41.60	June 15 ..	39.00	July 17 ..	38.02	Aug. 18...	21.11	Sept 19...	6.20
May 15...	41.50	June 16 ..	39.00	July 18 ..	37.10	Aug. 19...	21.40	Sept. 20...	5.10
May 16 ..	41.30	June 17 ..	39.10	July 19 ..	37.10	Aug. 20...	20.10	Sept. 21...	5.60
May 17...	41.10	June 18 ..	39.10	July 20 ..	36.40	Aug. 21 ..	20.20	Sept. 22...	5.20
May 18...	40.10	June 19 ..	39.20	July 21 ..	....	Aug. 22...	19.40	Sept. 23...	4.10
May 19 ..	40.60	June 20 ..	39.40	July 22 ..	35.70	Aug. 23...	19.20	Sept. 24...	4.60
May 20...	40.10	June 21 ..	39.50	July 23 ..	34.10	Aug. 24...	18.60	Sept. 25...	4.40
May 21...	39.70	June 22 ..	39.50	July 24 ..	34.40	Aug. 25...	18.00	Sept. 26...	4.00
May 22...	39.00	June 23 ..	39.60	July 25 ..	34.20	Aug. 26...	17.40	Sept. 27...	3.10
May 23...	38.50	June 24 ..	39.60	July 26 ..	34.10	Aug. 27...	16.10	Sept. 28...	3.80
May 24...	37.11	June 25 ..	39.90	July 27 ..	34.00	Aug. 28...	16.00	Sept. 29...	3.70
May 25 ..	37.70	June 26 ..	39.80	July 28 ..	33.11	Aug. 29...	15.50	Sept. 30 ..	2.50
May 26...	37.70	June 27 ..	39.80	July 29 ..	33.60	Aug. 30...	14.90	Oct. 1...	3.40
May 27...	37.80	June 28 ..	39.70	July 30 ..	33.00	Aug. 31...	14.20	Oct. 2...	3.20
May 28...	37.11	June 29 ..	39.70	July 31 ..	31.50	Sept. 1...	13.80	Oct. 3...	2.10
May 29...	38.00	June 30 ..	39.70	Aug. 1...	30.30	Sept. 2...	13.20	Oct. 4...	3.00
May 30...	38.20	July 1 ..	39.00	Aug. 2...	29.00	Sept. 3...	12.10	Oct. 5...	2.11
May 31...	38.40	July 2 ..	39.60	Aug. 3...	27.00	Sept. 4...	12.40	Oct. 6...	2.11
June 1 ..	38.00	July 3 ..	39.60	Aug. 4...	26.90	Sept. 5...	11.11	Oct. 7...	3.11
June 2 .	38.60	July 4 ..	39.60	Aug. 5...	25.60	Sept. 6...	....	Oct. 8...	3.20
June 3 ..	38.70	July 5 ..	39.60	Aug. 6...	24.60	Sept. 7...	....	Oct. 9...	3.20
June 4 ..	38.70	July 6 ..	39.70	Aug. 7...	23.70	Sept. 8...	10.20	Oct. 10...	3.30
June 5 ..	38.80	July 7 ..	39.70	Aug. 8...	23.00	Sept. 9...	9.70		

TABLE No. 2.—*Showing fill every* 100 *feet on King's Bar* (*or section* 1 *continued*) *from* 1882 *to* 1883.

Distance.	Fill.	Distance.	Fill.	Distance.	Fill.
Feet.	*Feet.*	*Feet.*	*Feet.*	*Feet.*	*Feet.*
100	13.0	1,000	9.4	1,900	18.5
200	12.0	1,100	8.4	2,000	14.0
300	*14.0	1,200	8.5	2,100	12.6
400	17.0	1,300	8.2	2,200	12.8
500	18.8	1,400	9.1	2,300	9.6
600	18.6	1,500	9.5	2,400	†9.2
700	16.6	1,600	11.6	2,500	8.4
800	14.0	1,700	14.2	2,600	6.4
900	12.0	1,800	17.6	2,700	6.4

* Middle of canal. † Middle of west pass.

TABLE No. 3.—*The maximum fill, in inner harbor, within the limits of canal, from* 1877 *to* 1883, *omitting sections sounded in* 1880, *which are not accurate enough for comparison.*

Sections.	Fill, in feet.				
	1877 to 1878.	1878 to 1879.	1879 to 1881.	1881 to 1882.	1882 to 1883.
No. 4........	20	12	12	6	6
No. 12........	13	12	Approx. 0	4	8
No. 14........	17	7	Approx. 0	2	9
No. 15........	13	10	Approx. 0	1	10
No. 16........	16	6	Approx. 0	Approx. 1	10
No. 17........	6	5	Approx. 0	Approx. 1	9
No. 24........	22	13	1879 to 1883. 16	Approx. 0	Approx. 5

TABLE No. 4.—*Fill in inner harbor within the limits of the slopes of canal and basin from* 1881 *to* 1882 (*see profiles*). *In the fractions, the numerator denotes the distance measured from the shore edge of the slope, the denominator, the fill at that distance.*

Sections.	Fill in feet.																	
No. 1	0	45	70	95	100	145	175	195	245	295	300							
	0	5.3	8.6	9.7	11.0	10.6	10.4	8.2	3.8	06	0.0							
No. 2	0	50	100	150	200	250	300	350	370	400	410	450	460	500	550	580		
	0	0.8	2.4	5.0	10.0	5.8	2.0	5.2	7.2	10.4	11.0	11.2	11.8	7.9	3.0	0.0		
No. 3	0	25	75	125	175	225	275	325	375	425	4.75	525						
	02	1.4	2.6	4.5	5.9	6.8	8.6	9.1	10.0	7.0	5.0	0						
No. 4	0	10	60	110	160	210	260	310	360	410	460	510	530	560	587			
	0	1.2	3.5	3.4	5.2	6.0	6.0	5.2	5.0	5.2	6.0	5.8	6.0	3.0	0			
No. 5	0	20	50	60	100	150	200	300	350	400	450	500	550	590				
	0	2.4	1.4	1.1	3.8	6.4	5.0	4.0	5.6	4.4	5.2	5.8	5.0	0				
No. 6	0	50	100	150	200	250	300	350	400	450	500	550	570	600	605			
	0	0.8	1.0	1.1	1.8	2.0	2.6	2.8	2.8	3.8	3.8	3.8	3.8	0.4	0			
No. 7	0	15	30	80	130	1.80	2.30	280	330	380	430	480	530	550	565			
	0	4.8	2.6	1.2	0.4	1.6	1.4	2.0	24	2.4	2.4	2.6	2.2	2.0	0			
No. 8	0	8	30	50	80	95	130	180	230	280	300	330	380	430	455	475		
	0	2.8	2.4	2.0	2.4	2.6	2.4	1.8	2.8	2.8	2.8	2.2	2.6	2.4	2.6	0		
No. 9	0	16	30	80	130	180	230	280	330	380	430	480	495	530				
	0	4.8	3.2	3.6	4.2	4.0	4.0	4.0	4.2	4.4	3.6	3.8	4.0	0				
No. 10	0	10	60	110	160	185	210	260	310	360	410	460	510					
	0	1.6	1.0	1.0	1.0	0.8	1.8	3.4	4.0	4.1	4.4	5.0	0					
No. 11	0	10	60	110	160	210	260	310	360	410	450	460	475					
	0	1.0	3.2	2.0	4.6	3.2	2.6	2.0	2.4	3.0	3.2	1.6	0					
No. 12	0	10	60	110	160	210	260	310	360	410	445							
	0	0.8	0.6	0.8	1.2	2.8	4.0	3.4	3.4	3.6	0							
No. 13	0	15	65	85	115	165	215	265	315	365	415	443	465					
	0	3.2	5.0	6.0	3.4	3.0	3.2	3.2	2.8	2.6	2.8	2.8	0					
No. 14	0	10	50	75	100	150	200	250	300	350	400	450	500	550	600	650	700	710
	0	3.6	2.0	1.6	2.6	1.6	1.4	0.8	0.2	0.8	0.9	1.0	0.8	1.4	1.2	1.2	0.8	0
No. 15	0	50	100	150	200	250	300	350	400	450	475	480						
	0	0.4	0.8	0.4	0.0	0.1	0.6	0.1	0.4	0.6	1.0	0						

See Table No. 5 showing mean fill and areas, calculated from above co-ordinates.

TABLE No. 5.—*Mean fill and areas of fill in inner harbor within the limits of the slopes of the canal and basin from* 1881 *to* 1882.

Section.	Mean fill.	Area.
	Feet.	*Sq. feet*
No. 1	6.2	1967.5
No. 2	6.0	3195.5
No. 3	5.6	3052.5
No. 4	4.0	2749.5
No. 5	3.6	2581.5
No. 6	2.0	1360.0
No. 7	1.8	1008.5
No. 8	2.1	1127.9
No. 9	3.4	2007.5
No. 10	2.1	1318.0
No. 11	2.2	1265.0
No. 12	1.8	987.0
No. 13	2.9	1484.2
No. 14	1.2	881.5
No. 15	0.3	177.5

See Table No. 4 for co-ordinates.

TABLE No. 6.—*Ordinates and distances within the limits of the slopes of canal and basin, and the lines of bottoms of canal and lake in 1883, including dredged volumes. In the fractions, the numerator, denotes the distances measured from the shore edge of the slope, the denominator, the ordinates at that distance.*

Section.	Ordinates and distances.																			
No. 1	$\frac{0}{0}$	$\frac{10}{5.2}$	$\frac{50}{5.4}$	$\frac{100}{7.0}$	$\frac{150}{12.5}$	$\frac{200}{17.8}$	$\frac{250}{24.4}$	$\frac{262}{26.2}$	$\frac{300}{26.6}$	$\frac{350}{26.7}$	$\frac{387}{26.8}$	$\frac{400}{23.2}$	$\frac{450}{20.0}$	$\frac{500}{15.8}$	$\frac{550}{11.0}$	$\frac{600}{6.6}$	$\frac{650}{0}$			
No. 2	$\frac{0}{0}$	$\frac{50}{12.4}$	$\frac{100}{18.2}$	$\frac{150}{23.0}$	$\frac{200}{27.6}$	$\frac{232}{31.2}$	$\frac{250}{30.6}$	$\frac{300}{30.5}$	$\frac{350}{30.5}$	$\frac{357}{30.5}$	$\frac{400}{27.2}$	$\frac{450}{22.2}$	$\frac{500}{17.4}$	$\frac{580}{12.8}$	$\frac{600}{7.0}$	$\frac{650}{1.8}$	$\frac{662}{0}$			
No. 3	$\frac{0}{0}$	$\frac{15}{2.4}$	$\frac{65}{8.8}$	$\frac{115}{24.4}$	$\frac{125}{26.4}$	$\frac{160}{29.8}$	$\frac{165}{29.7}$	$\frac{215}{29.8}$	$\frac{265}{29.9}$	$\frac{285}{30.2}$	$\frac{315}{27.6}$	$\frac{365}{22.7}$	$\frac{415}{18.2}$	$\frac{465}{14.0}$	$\frac{515}{9.2}$	$\frac{565}{4.2}$	$\frac{605}{0}$			
No. 4	$\frac{0}{0}$	$\frac{30}{4.6}$	$\frac{80}{12.2}$	$\frac{100}{16.2}$	$\frac{130}{18.6}$	$\frac{180}{22.2}$	$\frac{230}{27.8}$	$\frac{255}{30.8}$	$\frac{280}{30.6}$	$\frac{330}{30.5}$	$\frac{380}{30.4}$	$\frac{430}{24.4}$	$\frac{480}{18.4}$	$\frac{530}{14.4}$	$\frac{580}{9.4}$	$\frac{630}{4.0}$	$\frac{660}{0}$			
No. 5	$\frac{0}{0}$	$\frac{50}{8.8}$	$\frac{100}{23.6}$	$\frac{150}{28.6}$	$\frac{165}{30.6}$	$\frac{200}{30.4}$	$\frac{250}{30.1}$	$\frac{300}{30.2}$	$\frac{350}{30.5}$	$\frac{365}{30.6}$	$\frac{400}{25.4}$	$\frac{450}{22.2}$	$\frac{500}{16.8}$	$\frac{550}{11.2}$	$\frac{600}{5.0}$	$\frac{640}{0}$				
No. 6	$\frac{0}{0}$	$\frac{50}{6.8}$	$\frac{100}{20.8}$	$\frac{150}{25.2}$	$\frac{195}{30.2}$	$\frac{200}{30.2}$	$\frac{250}{30.1}$	$\frac{300}{30.3}$	$\frac{350}{30.5}$	$\frac{395}{31.0}$	$\frac{400}{31.0}$	$\frac{450}{24.8}$	$\frac{500}{19.8}$	$\frac{550}{14.0}$	$\frac{600}{8.0}$	$\frac{651}{1.6}$	$\frac{660}{0}$			
No. 7	$\frac{0}{0}$	$\frac{30}{6.6}$	$\frac{80}{18.8}$	$\frac{120}{27.4}$	$\frac{130}{27.8}$	$\frac{160}{30.8}$	$\frac{180}{30.0}$	$\frac{230}{29.8}$	$\frac{280}{29.7}$	$\frac{330}{30.0}$	$\frac{360}{30.4}$	$\frac{380}{28.3}$	$\frac{430}{22.8}$	$\frac{480}{17.5}$	$\frac{530}{11.2}$	$\frac{580}{5.2}$	$\frac{620}{0}$			
No. 8	$\frac{0}{0}$	$\frac{10}{1.6}$	$\frac{30}{4.4}$	$\frac{60}{12.4}$	$\frac{105}{32.2}$	$\frac{110}{32.0}$	$\frac{160}{29.6}$	$\frac{210}{29.2}$	$\frac{260}{29.1}$	$\frac{305}{29.6}$	$\frac{310}{29.7}$	$\frac{360}{23.8}$	$\frac{410}{18.6}$	$\frac{460}{13.0}$	$\frac{510}{7.8}$	$\frac{560}{1.0}$	$\frac{570}{0}$			
No. 9	$\frac{0}{0}$	$\frac{50}{11.2}$	$\frac{100}{19.2}$	$\frac{150}{33.4}$	$\frac{200}{30.2}$	$\frac{250}{29.6}$	$\frac{300}{29.2}$	$\frac{350}{29.4}$	$\frac{400}{23.6}$	$\frac{450}{18.2}$	$\frac{500}{12.8}$	$\frac{550}{7.0}$	$\frac{600}{1.0}$	$\frac{610}{0}$						
No. 10	$\frac{0}{0}$	$\frac{50}{8.0}$	$\frac{100}{16.8}$	$\frac{150}{27.2}$	$\frac{165}{30.2}$	$\frac{200}{28.9}$	$\frac{250}{28.7}$	$\frac{300}{28.6}$	$\frac{350}{28.6}$	$\frac{365}{28.6}$	$\frac{400}{24.4}$	$\frac{450}{18.2}$	$\frac{500}{12.4}$	$\frac{550}{6.6}$	$\frac{600}{0.6}$	$\frac{605}{0}$				
No. 11	$\frac{0}{0}$	$\frac{50}{9.4}$	$\frac{100}{21.2}$	$\frac{150}{30.0}$	$\frac{200}{29.2}$	$\frac{250}{28.4}$	$\frac{300}{28.1}$	$\frac{350}{27.8}$	$\frac{400}{21.2}$	$\frac{450}{15.0}$	$\frac{500}{8.8}$	$\frac{550}{2.4}$	$\frac{570}{0}$							
No. 12	$\frac{0}{0}$	$\frac{30}{8.8}$	$\frac{80}{25.6}$	$\frac{90}{30.2}$	$\frac{130}{29.4}$	$\frac{180}{28.3}$	$\frac{230}{28.0}$	$\frac{280}{27.7}$	$\frac{290}{27.7}$	$\frac{330}{23.0}$	$\frac{380}{17.0}$	$\frac{430}{11.2}$	$\frac{480}{5.4}$	$\frac{525}{0}$						
No. 13	$\frac{0}{0}$	$\frac{50}{6.6}$	$\frac{100}{21.2}$	$\frac{130}{30.4}$	$\frac{150}{29.4}$	$\frac{200}{28.9}$	$\frac{250}{28.3}$	$\frac{300}{28.1}$	$\frac{330}{28.1}$	$\frac{350}{26.0}$	$\frac{400}{19.4}$	$\frac{450}{12.8}$	$\frac{500}{6.4}$	$\frac{550}{0}$						
No. 14	$\frac{0}{0}$	$\frac{25}{7.4}$	$\frac{75}{21.6}$	$\frac{110}{32.2}$	$\frac{125}{31.0}$	$\frac{175}{28.4}$	$\frac{225}{27.6}$	$\frac{275}{27.4}$	$\frac{325}{27.2}$	$\frac{375}{27.0}$	$\frac{425}{27.0}$	$\frac{475}{27.0}$	$\frac{525}{27.0}$	$\frac{560}{27.0}$	$\frac{575}{25.4}$	$\frac{623}{19.0}$	$\frac{675}{13.0}$	$\frac{725}{6.6}$	$\frac{775}{0}$	
No. 15	$\frac{0}{0}$	$\frac{45}{5.6}$	$\frac{95}{14.6}$	$\frac{145}{25.2}$	$\frac{160}{29.4}$	$\frac{195}{27.4}$	$\frac{245}{26.6}$	$\frac{295}{26.4}$	$\frac{345}{26.2}$	$\frac{395}{26.0}$	$\frac{445}{26.0}$	$\frac{495}{26.0}$	$\frac{545}{26.0}$	$\frac{595}{26.0}$	$\frac{610}{26.0}$	$\frac{645}{21.4}$	$\frac{695}{15.2}$	$\frac{745}{9.0}$	$\frac{795}{2.4}$	$\frac{813}{0}$
No. 16	$\frac{0}{0}$	$\frac{50}{7.2}$	$\frac{100}{14.4}$	$\frac{150}{26.8}$	$\frac{160}{28.8}$	$\frac{200}{26.4}$	$\frac{250}{25.8}$	$\frac{300}{25.4}$	$\frac{350}{25.2}$	$\frac{400}{25.0}$	$\frac{450}{25.0}$	$\frac{500}{25.0}$	$\frac{550}{25.0}$	$\frac{600}{25.0}$	$\frac{610}{25.0}$	$\frac{650}{19.4}$	$\frac{700}{13.2}$	$\frac{750}{7.2}$	$\frac{800}{1.0}$	$\frac{810}{0}$
No. 17	$\frac{0}{0}$	$\frac{50}{8.2}$	$\frac{100}{21.0}$	$\frac{115}{28.0}$	$\frac{150}{25.5}$	$\frac{200}{24.5}$	$\frac{250}{24.5}$	$\frac{300}{24.5}$	$\frac{350}{24.0}$	$\frac{400}{24.0}$	$\frac{450}{24.0}$	$\frac{500}{24.0}$	$\frac{550}{24.0}$	$\frac{565}{24.0}$	$\frac{600}{20.0}$	$\frac{650}{14.0}$	$\frac{700}{8.0}$	$\frac{750}{1.6}$	$\frac{765}{0}$	
No. 18	$\frac{0}{0}$	$\frac{10}{1.2}$	$\frac{60}{7.2}$	$\frac{110}{13.2}$	$\frac{160}{19.4}$	$\frac{190}{22.2}$	$\frac{210}{22.2}$	$\frac{260}{22.2}$	$\frac{310}{22.2}$	$\frac{340}{22.1}$	$\frac{360}{20.8}$	$\frac{410}{14.2}$	$\frac{460}{8.2}$	$\frac{510}{1.6}$	$\frac{520}{0}$					
No. 19	$\frac{0}{0}$	$\frac{5}{0.6}$	$\frac{55}{6.5}$	$\frac{105}{13.5}$	$\frac{155}{20.0}$	$\frac{165}{21.0}$	$\frac{205}{21.2}$	$\frac{255}{21.2}$	$\frac{305}{21.2}$	$\frac{315}{21.2}$	$\frac{355}{16.5}$	$\frac{405}{10.0}$	$\frac{455}{3.2}$	$\frac{475}{0}$						
No. 21	$\frac{0}{0}$	$\frac{28}{3.8}$	$\frac{78}{9.0}$	$\frac{128}{14.8}$	$\frac{163}{18.0}$	$\frac{178}{18.0}$	$\frac{228}{18.0}$	$\frac{278}{18.0}$	$\frac{313}{18.1}$	$\frac{328}{15.5}$	$\frac{378}{8.5}$	$\frac{428}{2.0}$	$\frac{443}{0}$							
No. 23	$\frac{0}{0}$	$\frac{20}{2.4}$	$\frac{70}{7.8}$	$\frac{120}{13.7}$	$\frac{160}{18.4}$	$\frac{170}{18.3}$	$\frac{220}{17.7}$	$\frac{270}{17.5}$	$\frac{310}{17.5}$	$\frac{320}{16.0}$	$\frac{370}{10.0}$	$\frac{420}{3.6}$	$\frac{450}{0}$							

See Table No. 7 for mean ordinates, areas, distance between sections and volumes.

TABLE NO. 7.—*Estimates of canal and basin*, 1883; *table showing mean ordinates, areas, and volumes within the limits of the slopes of canal and basin, and the lines of bottoms of canal and lake in* 1883, *including dredged volume.*

Sections.	Mean ordinate.	Area.	Distance between sections.	Quantities.
				Cubic yards.
No. 1	15.1	10,082.0	520	74,997.5
No. 2	19.0	13,058.8	381	162,815.4
No. 3	18.1	11,046.2	492	219,363.0
No. 4	17.3	12,365.0	475	205,822.8
No. 5	20.2	12,968.2	265	137,056.0
No. 6	19.7	13,466.7	372	182,096.7
No. 7	20.4	12,905.5	422	206,078.2
No. 8	17.1	11,353.0	330	148,145.6
No. 9	17.5	12,220.0	232	101,225.8
No. 10	18.0	11,505.2	540	237,152.1
No. 11	17.0	11,039.0	300	125,236.5
No. 12	18.7	10,238.0	304	119,753.6
No. 13	19.0	10,493.5	405	155,482.6
No. 14	21.2	17,166.0	430	166,357.6
No. 15	19.2	16,854.6	439	276,571.6
No. 16	18.5	15,910.0	433	262,686.8
No. 17	18.1	14,733.2	340	192,890.8
No. 18	13.1	7,610.5	658	318,294.2
No. 19	12.6	6,676.0	418	110,509.2
No. 21	11.1	5,355.4	574	127,566.2
No. 23	11.0	5,333.5	766	151,622.6
		0	1,315	107,907.9
Total				3,789,632.7

See Table No. 6 for co-ordinates.

TABLE No. 8.—*Showing fill in inner harbor within the limits of the slopes of canal and basin from* 1882 *to* 1883 (*see profiles*). *In the fractions, the numerator, denotes the distance measured from the shore edge of the slope, the denominator, the fill at that distance within limits of proposed excavation.*

Sections.	Ordinates and distances.																					
No. 1	0	10	50	100	150	155	200	225	250	260	300	330	350	400	450	455	500	550	600	650		
	0	5.2	5.4	7.0	12.5	12.8	12.6	12.8	14.8	15.2	14.8	13.6	14.8	17.2	20.0	20.0	15.8	11.0	6.2	0		
No. 2	0	50	100	150	200	250	300	350	370	400	410	450	475	500	550	585	600	650	662			
	0	1.0	2.2	5.2	4.0	5.6	7.4	8.4	9.2	8.4	8.4	9.4	10.2	9.2	9.2	8.6	6.6	1.0	0			
No. 3	0	15	35	65	115	165	215	265	315	365	415	465	515	565	605							
	0	2.4	4.0	2.0	3.0	2.6	3.6	5.0	5.2	5.4	5.0	5.0	4.4	4.0	0							
No. 4	0	20	30	80	130	180	230	280	330	380	430	480	530	580	610	630	660					
	0	3.2	2.8	3.0	4.8	3.4	4.2	4.6	5.4	5.4	5.4	5.4	6.2	6.4	6.6	3.8	0					
No. 5	0	50	60	100	150	200	250	300	350	400	450	500	550	585	600	640						
	0	4.0	4.4	4.0	4.0	5.4	5.0	5.0	2.8	4.6	5.6	5.8	6.2	6.8	5.0	0						
No. 6	0	50	100	150	200	250	300	350	400	450	475	500	550	600	605	650	660					
	0	4.8	5.2	4.8	4.2	4.8	5.6	5.6	6.4	6.4	5.8	6.2	7.2	7.6	7.2	1.6	0					
No. 7	0	30	80	130	140	180	230	280	330	380	430	480	530	565	580	620						
	0	1.6	4.0	6.0	6.0	4.6	5.8	5.8	5.8	6.0	6.6	7.0	7.6	7.4	5.2	0						
No. 8	0	10	30	60	80	110	130	160	210	260	310	335	360	410	460	510	560	570				
	0	1.6	4.4	4.0	5.2	5.4	5.2	5.0	6.2	6.4	6.6	7.2	7.4	7.2	7.8	7.8	1.0	0				
No. 9	0	20	50	100	150	200	250	300	350	400	450	500	550	600	610							
	0	2.8	2.6	3.0	4.0	3.8	5.6	6.2	7.2	6.6	7.2	7.0	7.0	1.0	0							
No. 10	0	40	50	100	150	200	225	250	300	350	400	450	500	556	600	605						
	0	4.8	5.4	4.6	5.8	7.0	8.2	8.0	8.2	8.0	7.4	7.2	6.8	6.6	0.6	0						
No. 11	0	40	50	100	150	200	250	300	350	400	450	500	515	550	570							
	0	6.4	6.6	5.2	7.0	7.6	7.8	7.8	8.0	7.6	7.4	7.0	6.8	2.4	0							
No. 12	0	30	80	130	180	230	280	330	380	430	460	480	525									
	0	7.2	7.4	7.8	8.4	8.0	7.8	7.8	7.8	7.4	7.4	5.4	0									
No. 13	0	35	50	100	120	150	200	250	300	350	400	450	490	500	550							
	0	2.8	2.6	3.0	2.9	6.0	8.0	7.6	7.8	8.4	8.4	8.2	7.8	6.4	0							
No. 14	0	25	75	100	125	175	225	275	325	375	425	475	525	575	625	675	725	785	775			
	0	7.4	6.6	6.0	4.4	8.0	8.0	8.6	9.5	9.4	8.8	8.0	7.4	6.8	6.3	5.6	5.2	5.1	0			
No. 15	0	25	45	95	145	170	195	245	295	345	370	395	445	495	545	595	645	695	745	777	795	813
	0	2.0	2.2	3.2	5.2	6.0	5.8	6.7	8.8	9.0	9.0	9.4	10.0	10.4	9.2	7.4	7.2	6.5	5.4	4.8	2.4	0
No. 16	0	30	50	100	150	200	225	250	300	325	350	400	450	500	550	600	650	700	750	770	800	810
	0	3.8	3.8	1.0	2.6	2.8	5.8	7.2	8.2	8.5	8.7	9.4	10.2	8.4	8.0	7.4	6.3	5.6	5.2	5.0	1.0	0
No. 17	0	10	50	100	150	175	200	250	300	350	400	450	500	550	600	650	700	728	750	765		
	0	1.4	2.0	2.0	3.2	4.2	7.7	6.8	7.6	9.3	9.3	9.3	8.4	7.4	6.3	5.5	4.8	4.4	1.6	0		
No. 18	0	10	60	110	160	185	210	260	285	310	360	410	460	478	510	520						
	0	1.2	5.8	5.8	5.6	7.6	7.6	7.6	7.6	7.2	6.2	6.0	6.2	6.2	1.6	0						
No. 19	0	5	50	55	105	155	205	255	305	355	405	435	455	475								
	0	0.6	5.7	5.6	6.0	5.4	6.2	6.4	6.4	6.2	6.2	5.6	3.2	0								
No. 21	0	28	48	78	128	178	228	278	328	378	408	428	448									
	0	3.8	5.6	5.2	4.4	5.2	5.4	5.4	5.2	4.8	4.8	2.0	0									
No. 23	0	20	50	70	120	170	220	270	320	370	410	420	450									
	0	2.4	2.4	5.2	5.2	5.2	4.8	5.2	5.0	5.0	4.8	3.6	0									

See Table No. 9 for mean ordinates, maximum ordinates, areas, distances between sections, volumes.

TABLE No. 9.—*Showing fill in inner harbor from* 1882 *to* 1883, *within the limits of the slopes of canal and basin, mean ordinates, maximum ordinates, areas, distance between sections, volumes.*

Sections.	Maximum ordinates.	Mean ordinates.	Areas.	Distance between sections.	Quantities.
					Cubic yards.
No. 1	17.2	11.6	7,683.2	520	53,916.3
No. 2	10.2	6.0	3,929.0	381	80,464.8
No. 3	5.4	3.4	2,362.0	402	56,716.7
No. 4	6.6	4.2	3,038.0	475	47,375.7
No. 5	6.8	4.3	2,891.0	265	31,370.1
No. 6	7.6	4.9	3,480.5	372	43,829.9
No. 7	7.6	5.0	3,302.0	422	52,996.9
No. 8	7.8	4.9	3,334.0	330	40,553.8
No. 9	7.2	4.3	3,084.0	232	27,566.7
No. 10	8.2	5.5	3,796.0	540	68,678.0
No. 11	8.0	5.8	3,741.5	300	41,874.4
No. 12	8.4	6.3	3,694.5	304	41,861.9
No. 13	8.4	5.3	3,338.0	405	52,722.0
No. 14	9.5	6.4	5,443.5	430	56,890.6
No. 15	10.4	5.9	5,454.1	439	88,593.4
No. 16	10.2	5.4	4,866.4	433	82,711.0
No. 17	9.3	5.1	4,563.0	340	59,460.2
No. 18	7.6	5.1	3,055.4	658	98,369.2
No. 19	6.4	4.5	2,593.5	418	43,677.9
No. 21	5.4	4.0	2,066.2	574	49,425.6
No. 23	5.2	3.8	2,064.0	766	58,587.7
			0	1,315	39,659.5
Total					1,255,486.4

See Table No. 8 for co-ordinates.

TABLE No. 10.—*The amount of material excavated each month by the dredge, the amount taken from the basin, temporary canal, and West Pass, and totals.*

Dredging.	Cubic yards.
Material dredged during April	52,715
Material dredged during May	83,635
Material dredged during June	60,589
Material dredged during July	83,354
Material dredged during August	35,590
Material dredged during September	34,152
Total	350,035
Material taken from basin	244,456
From canal to deep water in lake	90,662
Taken from West Pass	14,917
Total	350,035

L 4.

REPORT OF H. D. GARDEN, ASSISTANT ENGINEER, UPON LEVEE WORK ON THE TENSAS FRONT, THIRD DISTRICT.

UNITED STATES ENGINEER OFFICE,
Vicksburg, Miss., October 8, 1883.

SIR: In compliance with your instructions of the 3d instant, to "prepare a concise report of levee work on the Tensas Front, for embodiment in the annual report of the Commission," I have the honor to submit the following tabulated statement and remarks on the levees under my direction in Louisiana:

TABULATED STATEMENT.

Levees, Tensas front, in Louisiana, Third District.

Names of levees.	Average height.	Length of levee.	Contents (completed).	Amount, November 1, 1883, yet necessary to complete.
		Feet.	*Cubic yards.*	*Cubic yards.*
Upper Providence	6	7,283	46,857.7	....
Hagaman Point	7	1,963	14,305.2	....
Wilton to Raleigh	12.5	23,588	343,087.7	99,381.6
Raleigh to Willow Point	....	9,648	41,287.7	....
Omega	9	16,310	199,059.7	....
Cabin Teele	6.5	13,621	90,002.2	....
Sparta	6	6,771	39,156.9	....
Delta to Bedford	9	28,287	243,903.3	....
Panther Forest	....	26,880	163,182.0	....
Duffin Break	6.7	10,960	80,246.0	....

Names of levees.	Width of crown.	Front slopes.	Back slopes.	Height of net grades above high-water mark of 1882.	Height of gross or shrinkage grade above high-water mark of 1882.
	Feet.			*Feet.*	*Feet.*
Upper Providence	8	3 to 1	3 to 1	1.5	2.7
Hagaman Point	8	3 to 1	3 to 1	1.5	2.9
Wilton to Raleigh	8 and 6	3, 4, and 5 to 1	3 to 1	1.5	4.0
Raleigh to Willow Point	8	3 to 1	3 and 2½ to 1	1.5	....
Omega	8 and 7	3 to 1	3 and 2½ to 1	0.5	2.3
Cabin Teele	8 and 6	3 to 1	3 and 2½ to 1	0.5	1.8
Sparta	8 and 7	3 to 1	3 to 1	1.1	2.3
Delta to Bedford	6	3 to 1	2½ to 1	0.5	2.3
Panther Forest	8, 6, and 8	3, 3½, and 2 to 1	2½, 2 and 1½ to 1	.53	....
Duffin Break	8	3½ to 1	2½ and 2 to 1	.3	1.5

NAME OF LEVEES AND REMARKS.

Upper Providence levee, East Carroll Parish, Louisiana.—About 3 miles above the town of Providence. Work began November, 1882. Completed February, 1883.

Hagaman Point levee, East Carroll Parish, Louisiana.—About 2½ miles below the town of Providence. Work began February, 1883. Completed March, 1883. Pending the construction of this work, a temporary protection levee was ordered here containing 2,029$\frac{4}{10}$ cubic yards.

Wilton to Raleigh levee, East Carroll Parish, Louisiana.—Work began on this levee in October, 1882, and with as large a force as the contractors could collect, progressed from each end towards the center, until the suspension on account of the flood in March, 1883, at which time there was a gap of 1½ miles on which very little work had been done. The river bank along this front is very low, and the water rising rapidly in February it was deemed impossible with the force on hand (between four and five hundred men) to fill up the gap before the overflow; protection levees were therefore ordered to connect the new work with the "Old Front levee." The upper protection sustained the pressure of the water and saved all the work above it, but the lower one succumbed to the fast rising flood, and the strong current rushing rapidly through the main line swept away 31,552 cubic yards before its destructive effects could be arrested. It has since been found inexpedient, on account of insufficient funds, to continue the levee on the originally projected line, and a new line has been adopted connecting the main work with the Old Front levee, which, on inspection of the bank in front and with the necessary repairs, is found to be entirely safe and practicable. Work was resumed on this levee in September with a considerable force of teams and scrapers, and in all probability it will be completed by December 15, 1883.

Raleigh to Willow Point levee, East Carroll Parish, Louisiana.—Work here consists in repairs of an old levee and filling up a number of short gaps in the same. Began November, 1882, completed February, 1883.

Omega levee, Madison Parish, Louisiana.—Two miles above Milliken's Bend. Work commenced October, 1883. Suspended in March, 1883. No damage done by the flood. Contractor expects to resume work at once, and ought to complete the levee in a month.

Cabin Teele levee, Madison Parish, Louisiana.—One mile below Milliken's Bend. Work began November, 1882. Completed February, 1883.

Sparta levee, Madison Parish, Louisiana, near Duckport.—Work began in November, 1882. Completed February, 1883.

Delta and Bedford levee, Madison Parish, Louisiana. Begins at Delta opposite Vicksburg, Miss.

Work began November, 1882. Suspended March 24, 1883, on account of high water, lacking 48,428 cubic yards of completion. Resumed in July and completed in October, 1883. This work was very far advanced when the river began to rise in February, but a gap of 1,100 feet still remained, on which scarcely any work had been done, rendering the entire condition of the new levee (composed of a soft, sandy material) very precarious should a torrent of water succeed in rushing through the main line. This made the construction of a protection levee along a portion of the river bank in front of the exposed points, and connecting with the completed work, an absolute necessity, and by diligently watching and keeping up this protection for a period of nearly four months the entire work was finally saved.

GENERAL REMARKS.

The construction of these works has been required to be of the most substantial character. After location of the line, the ground is thoroughly cross-sectioned for the purpose of slope-staking and obtaining accurate results in the calculation of cubic contents. A muck ditch is cut near the center line to stop all leakage that might occur from crayfish holes or vegetable matter imbedded in the soil; an addition of one-fifth of the net height is put on for shrinkage and the faces well sodded with live Bermuda grass before the levee is accepted.

On account of the limited amount of funds appropriated for each of the above levees in only one instance (that of Wilton and Raleigh, which is a low and dangerous point) was the net grade line put above the level of the old levees adjoining, nor do I think it would have been advisable to raise them any higher unless the entire length of the levee on the Louisiana shore in this district could have been raised and enlarged simultaneously.

It will be seen from an inspection of the table that high-water mark of 1882 was very near the crown of the levee at nearly all these points, and that, too, when the flood line must have been very much lowered on the river by the discharge of an enormous volume of water through the Duffin, Panther Forest, Ashton, Wilton, and Raleigh, Omega, and Delta breaks, as well as those on the Yazoo front. It is more than probable that in the event of a similar flood, the recent closing of all these crevasses will raise the flood line above the top of the Louisiana levees as they now stand, at nearly all points, and cause a disastrous destruction of work already put up at such great expense. To render it entirely safe against an ordinary overflow, therefore, will require, in my opinion, an additional average height of 3 feet, with corresponding enlargements all along the entire length of the levee. In the absence of a continuous levee survey from a point opposite Warrenton to the Arkansas line, I can only give an approximate estimate of the amount of material necessary, and cost. Assuming, which I think is nearly correct, the average dimensions of the levee to be 8 feet high, 7 feet crown, and 3 and 2½ to 1 slopes, to raise the same 3 feet with an 8-foot crown and 3 and 3 to 1 slopes would take 42,826 cubic yards per mile, at an average cost of 25 cents per yard, $10,706.50. Cost for 80 miles, which is about the length of the Louisiana levees in this district, $856,520. Add 20 per cent. for cost of new levees that may be necessary, and incidental expenses, $1,027,824.

Very respectfully, your obedient servant,

H. D. GARDEN,
Assistant Engineer.

Capt. W. L. MARSHALL,
Corps of Engineers, U. S. A.

L 5.

REPORT OF GEORGE M. HELM, ASSISTANT ENGINEER, UPON LEVEE WORK ON THE YAZOO FRONT, THIRD DISTRICT.

GREENVILLE, MISS., *November* 15, 1883.

SIR: In accordance with your request, the following report of operations under my charge on levee construction on the Yazoo front, third district, in connection with maps and profiles of each project of work done by the river commission, together with a portfolio profile of survey of levees sent on heretofore, is respectfully submitted.

This survey was commenced by the "Mississippi Levee Board" in March, 1882, and was under your instructions finished from Leota to the Warren County line, December 25, 1882. It covers the entire district of the "Mississippi Levee Board" from Totten's Ridge, north of Hushpukna, in Coahoma County, through Bolivar, Washington, and Issaquena Counties, to the Warren County line, a distance of 1,056,200 feet, or 204.04 miles.

Levees were run with reference to Memphis datum plane, and U. S. P. B. M., and the average fall of the river from Hushpukna to Greenville found to be 0.377 foot per mile, and from Greenville to the Warren County line 0.306 foot per mile. Average fall from upper to lower end of district 0.304 foot. Average height of levees above Greenville, not including Hushpukna and Lake Bolivar crossings, 8.05 feet; average height below Greenville, 6.06 feet; height of Hushpukna levee, 36 feet; height of Lake Bolivar levee, 24 feet.

The following statement will exhibit the length of levee constructed, amount of work embraced in estimates returned to date, and amount of cubic yards to complete same, with specifications of all work done in your district from October 1, 1882, to November 1, 1883:

Tabulated statement—Levees Yazoo front, in Mississippi—Third District.

Names of levees.	Length of levee.	Contents completed.	Amount November 1, 1883, yet necessary to complete.	Width of crown.	Front slopes.	Back slope.	Height of net grade above high-water mark of 1882.	Height of gross or shrinkage grade above high-water of 1882.
	Feet.	*Cubic yards.*	*Cubic yards.*	*Feet.*			*Feet.*	*Feet.*
Riverton levee	9,872	151,663	....	8	8 and 4 to 1	3 to 1	1.1	3.5
Beulah breaks—1 to 9 inclusive	4,009	27,152	....	8	8 and 4 to 1	3 to 1	0.4	1.09
Beulah to Riverton enlargement	18,700	66,836	....	8	3 to 1	3 to 1	1.8	2.15
Beulah to Hughs enlargement	26,610	150,538	....	8, 1, and 4	8, 4, and 5 to 1	2 and 3 to 1	1.28	1.60 5.58
Hughs break	1,756	22,882	....	8	3 to 1	3 to 1	1.4	3.3
Wade break	2,207	50,714	....	8	4 to 1	3 to 1	1.1	3.4
Clay and Bagot to Rowlands	41,140	96,015	7,283	8	8 and 4 to 1	2 and 3 to 1	1.42	1.72
Rowlands to Jenkins	42,919	156,213	....	8	8 and 4 to 1	2 and 3 to 1	1.76	2.33
Jenkins to Easton, including Bolivar bayou and Easton break	14,010	....	....	....	....	....	....	1.9
	969	....	....	....	....	....	....	3.7
	39	51,287	7,344	8	8 and 3 to 1	2 and 3 to 1	1.58	3.7
Longwood	4,980	75,891	....	8	4 to 1	3 to 1	3.87	5.93
Longwood protection	2,228	15,978	....	4 and 5	3 to 1	3 to 1	....	1.45
Skipwith	69,012	77,660	....	8	8 and 4 to 1	3 to 1	2.9	3.37
Elleslie	9,975	133,500	....	8 and 4	4 and 3 to 1	3 to 1	4.08	5.49
Elleslie protection	2,000	2,996	....	3	2 to 1	2 to 1	.05	1.0
Drainage ditch	....	218	....	....	....	....	....	....
Shiloh and new line at Arcadia	21,135	67,299	....	8, 4, 6, and 8 to 1	....	....	....	2.3
	4,044	....	....		3 to 1	2 and 3 to 1	2	2.2
Magna Vista to Chotard	22,985	....	....	....	....	....	....	2.48
Higgins break	3,265	49,857	....	4 and 6	3 to 1	2 and 3 to 1	2	3.0
Total	301,305	1,196,199						

NAMES OF LEVEES AND REMARKS.

Riverton levee, Bolivar County, Mississippi.—Two miles below Rosedale; average height, 9.59 feet; work began November, 1882, and completed January, 1883.

Beulah breaks, 1 to 9 inclusive.—On north bank Lake Beulah, Bolivar County, Mississippi; average height, 6.5 feet; work began October, 1882; completed December, 1882. The grade-line being fixed at the same as that of the old levees, was too low on several of these breaks, and after being finished had to be raised by the Levee Board to keep the water of 1883 from running over.

Beulah to Riverton enlargement, Bolivar County, Mississippi.—Average height, 1.72 feet; work began November, 1882; completed March, 1883.

Beulah to Hugh's enlargement, Bolivar County, Mississippi, including Clear Creek break.—Average height enlargement, 1.6; average height Clear Creek break, 21.6; work began November, 1882; not quite complete.

Hugh's break, south of Lake Beulah, Bolivar County, Mississippi.—Average height, 9.35; commenced work November, 1882; completed January, 1883.

Wade break, north of Lake Bolivar, Bolivar County, Mississippi.—Average height, 11.5; work began November, 1882; completed March, 1883.

Clay and Bagot to Rowlands (Catfish Point), Bolivar County, Mississippi.—Average height, 1.45; commenced work November, 1882; not yet completed.

Rowlands to Senkins, Catfish Point, Bolivar County, Mississippi.—Average height, 2.85; commenced work October, 1882; not yet completed.

Jenkins to Easton, opposite foot of Lake Bolivar, Choctaw Bend, Bolivar County, Mississippi—including Bolivar Bayou and Easton breaks.—Average height enlargement, 1.94; average height, Bolivar bayou, 11.2; average height, Easton break, 11.2.

Longwood levee, Washington County, Mississippi.—Protection levee, Washington County, Mississippi. Average height main levee, 10.33; average height protection, 7.26; commenced work November, 1882; completed January, 1883. The contractor not having the main levee completed in time for high water of 1883 a protection levee was constructed by the contractor.

Skipwith levee, Issaquena County, Mississippi.—Average height, 7.39; commenced work November, 1882; completed April, 1883. It was necessary to enlarge the old front levee as a protection to this point. This work was done by day labor, and the cost is represented by "pay-rolls" in your office.

Elleslie levee, Issaquena County, Mississippi; Elleslie protection, Issaquena County, Mississippi; drainage ditch.—Average height main levee, 9.08; commenced work November, 1882; completed July, 1883. That portion of the line connecting the main back levee with the front, being at right angles with the river, was built with a crown of only 4 feet.

Shiloh levee enlargement and new levee at Arcadia, Issaquena County, Mississippi.—Average height of enlargement, 1.41; average height, Arcadia, 6.64; commenced work November, 1882; completed March, 1883. The rapid caving of the river bank at Arcadia made it necessary to construct a new levee across an angle at that point.

Magna Vista to Chotards, Issaquena County, Mississippi; enlargement Higgins Break.—Average height of enlargement, 2.41; average height of Higgins break, 5.06; commenced work November, 1882; completed January, 1883.

In addition to the above-mentioned work done under your direction in the third district is the following in Coahoma County, which, being a small amount, is reported herewith, to avoid a separate report to Major A. M. Miller, Corps of Engineers, United States Army:

	Lake Charles levee.†	Parker's enlargement.*	Total.
Length of levee, feet	3,184	17,924	21,108
Contents completed, cubic yards	39,756	78,567	118,323
Width of crown, feet	6	8	....
Front slopes	3 to 1	3 and 4 to 1	....
Back slopes	3 to 1	2 and 3 to 1	....
Height of net grade above high water mark of 1882	1.86	2.3	....
Height of gross or shrinkage grade above high-water mark of 1882	3.86	2.87	....

*Average height 2.85. Commenced work November, 1882; completed, March, 1883.

†Average height 10 feet. Commenced work November, 1882; completed, January, 1883.

I acknowledge with pleasure the efficient manner in which my assistants, Messrs. W. L. Starling, Robert Somerville, E. Mason, J. S. Martin, and T. W. Helm, have performed their duty in the field. Also, I am indebted to W. L. Starling and Robert Blakemore for valuable services in the office.

Believing it will be a matter of general interest to know how the Mississippi Levee Board have carried out their promise, viz, that should their district receive an allotment from the Mississippi River Commission they would expend two hundred thousand ($200,000) dollars in levee construction and repairs, and being their representative also, I append a statement of the amount of the work done by them, embraced in estimates returned from July 10, 1882, to October 1, 1883, and cost of same, represented by abstract of secretary and treasurer's report.

I have also made an approximate estimate of earth-work required to raise the levees of this district 3 feet above high water of 1882, based upon a crown of 8 feet and slopes of 3 and 3 to 1.

Earthwork done and under contract by Mississippi Levee Board from July 10, 1882, *to October* 1, 1883.

	Length of levee.	Contents (completed.)	Contents October 1, 1883, yet necessary to complete.
	Feet.	*Cubic yards.*	*Cubic yards.*
In Coahoma County, Mississippi	57, 461	61, 348	15, 069
In Bolivar County, Mississippi	179, 156	553, 284	241, 804
In Washington County, Mississippi	51, 710	51, 497	241, 500
In Issaquena County, Mississippi	5, 871	30, 831	17, 207
Total	294, 198	696, 960	515, 580

	Width of crown.	Front slope.	Back slope.	Hight of net grade above high-water mark of 1882.
	Feet.			
In Coahoma County, Mississippi	3, 4, 6 and 8	3 to 1	2 and 3 to 1	2
In Bolivar County, Mississippi	15, 8, 6, 4, and 3	3, 4, and 5 to 1	2, 3, and 5 to 1	2.4
In Washington County, Mississippi	4, 6, and 8	3 and 4 to 1	2 and 3 to 1	2
In Issaquena County, Mississippi	3, 4, 6, and 8	2 and 3 to 1	2 and 3 to 1	2 and 3

Recapitulation of work done in Mississippi levee district.

	Length of levee.	Contents (completed).	Contents October 1, 1883, yet necessary to complete.
	Feet.	*Cubic yards.*	*Cubic yards.*
Work done by Mississippi River Commission in third district	301, 305	1, 223, 163	
Work done by Mississippi River Commission in Coahoma County, Mississippi	21, 108	118, 323	
Work done by Mississippi Levee Board on entire district	294, 198	696, 960	15, 580
Total	616, 611	2, 038, 446	

Estimate of earthwork required to raise the Mississippi levees 3 *feet above high water of* 1882, *based upon a crown of* 8 *feet, and slopes of* 3 *and* 3 *to* 1.

	Cubic yards.
From upper end of district to a point opposite White River	1, 091, 880
From White River to Greenville	1, 828, 899
From Greenville to Warren County line	1, 003, 350
Total amount necessary	3, 924, 129

Statement of cash disbursed by the Mississippi Levee Board, second Mississippi district, from July 1, 1882, to October 1, 1883.

General expense account	$1,721 08
Mileage and per diem	1,299 13
Officers' salaries	6,091 66
Engineers' salaries	4,375 00
Contingent engineering	5,217 78
Rights of way	27,327 14
Bolivar graduation (new levees)	110,005 29
Coahoma graduation (new levees)	7,469 54
Washington graduation (new levees)	2,143 15
Issaquena graduation (new levees)	7,639 68
Repairs and enlargement levees, Coahoma County	13,567 00
Repairs and enlargement levees, Bolivar County	56,258 11
Repairs and enlargement levees, Washington County	5,265 61
Repairing force (Bolivar and Washington)	18,533 49
Grading and repairing levees	5,842 42
Maintenance of levees	300 00
High water of 1882	8,878 04
High water of 1883	23,635 31
Commissions paid collector	5,213 42
Commissions paid sheriffs	697 97
Certificate of indebtedness paid	48,946 41
Interest paid	9,064 66
Cotton tax refunded	162 00
Land sales and redemptions refunded	476 40
Levee construction-tax	3 88
Old account settled by suit United States circuit court	520 83
Total	370,655 00

CONDITION OF LEVEES IN THE MISSISSIPPI LEVEE DISTRICT.

They are much better than ever heretofore, and when the work now under contract to be constructed by January 1, 1884, is finished they will stand from 1.1 to 2 feet above the high water line of 1882, with the exception of the nine breaks of Beulah, which are a tenth of a foot or so below. Most of the old levees, however, were built with slopes of 2 and 3 to 1, and with 6 feet crown. These have been raised in many instances, with same slopes, by merely capping, giving a crown of 3 and 4 feet. These, with all other levees in the district, except Lake Bolivar, should be enlarged to a crown of 8 feet with slopes of 3 and 4 to 1, with a grade of 3 feet above the high water of 1882, and all those built of buckshot or clay should have a cement wall inserted just above the high water line on the front slope extending down through the levee 4 or 5 feet below the natural surface.

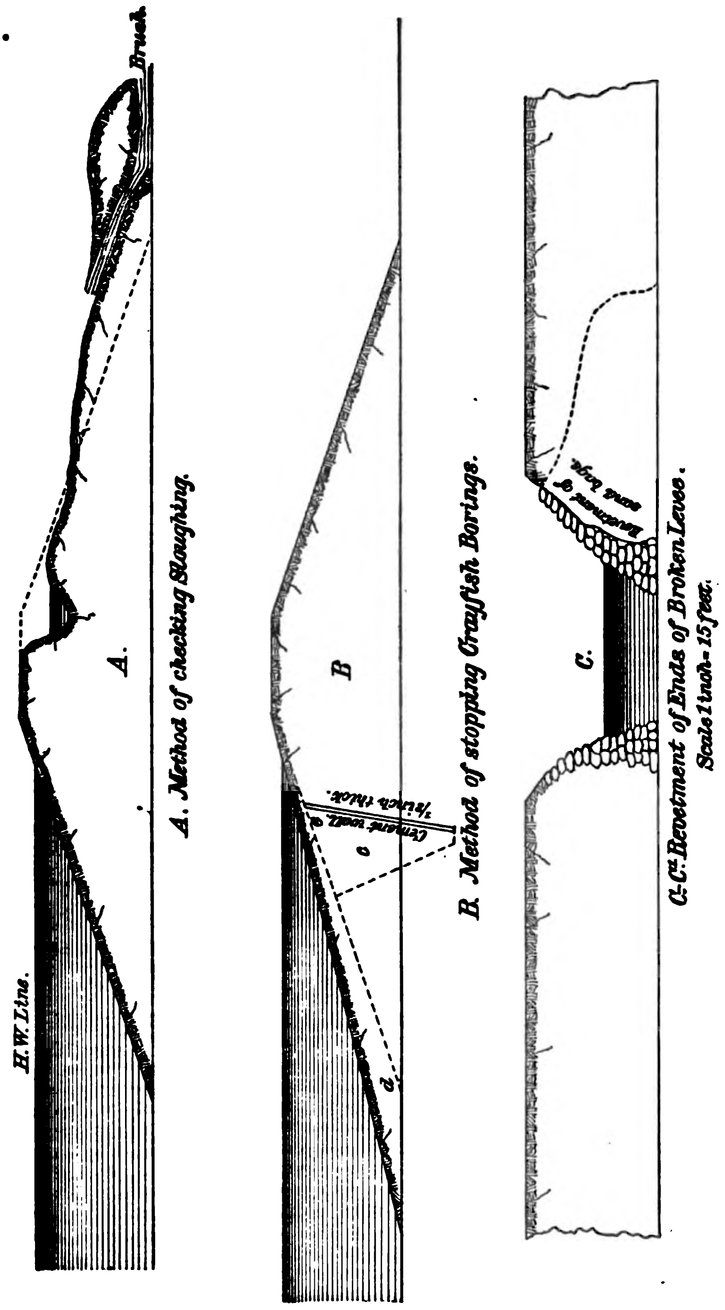
And not until this is done, nor until the Mississippi River Commission succeed in their plans of revetting the peninsulas, thus preventing cut-offs, can we hope for permanent levees of this character. They are too costly to build and abandon every ten or fifteen years, and we will have meanwhile to follow the old plan of temporizing with insecure levees, for it is well demonstrated that the normal, or that curvature that brings about an equilibrium rendering the banks stable, is of such small radius that it doubles upon itself by making a complete curve resulting in a *cut-off* and loss to the river of from 15 to 20 miles in distance—the result probably of a half century's work, besides producing an entire change in its regimen. At this stage the river commences at once to recover the distance and curvature lost, and, with a current accelerated by the increased fall, dashes against the banks, erodes and caves them in with the levees in excavating a new channel.

Stop cut-offs and the river will go steadily and continuously on without interruption in its work of adjusting its rapid current to the sandy soil of its banks by gentle curvature until an equilibrium is obtained. At this period a map of most sections of the river would resemble the letter S, there would be few reaches or tangents in its course but a system of reverse curves, the degree of curvature varying only with the characteristics of the soil.

We are now threatened by cut-offs at Caulk's Point, Ashbrook's Point and Tarpley. Should either of these occur it would precipitate others, and necessitate the enlargement and raising of all levees below with new locations and levees in many places on both sides of the river.

In accordance with your request the following illustrations are also appended and submitted herewith, viz, cross-sections A, B, and E of levees from autotype views; two, C and C^1, showing plan of revetting end of levee at crevasses, and two, D and E, showing front and end view of pile dam for closing crevasse:

Fig. 1.



A. Method of checking Sloughing.

B. Method of stopping Crayfish Borings.

C.–C. Revetment of Ends of Broken Levee.

Scale 1 inch = 15 feet.

Cross-section A.—Represents a sloughing levee, and illustrates the plan I have found most successful in treating same. They occur generally in new levees built of sandy loam mixed with quicksand; the latter is generally found 3½ or 4 feet below the surface, and specifications should provide against team or scraper pits of greater depth than 3 feet, except in clay or buckshot soil. B represents a brush mattress one foot in thickness resting upon the natural surface and foot of displaced slope, extending up the slope far enough to brace it, the brush being laid straight and at right angles to the line of levee; upon this brush the embankment C is constructed of sufficient weight to be stationary, to brace and hold the slope in place; the sipe water then passes off under the cbrea through the brush without loss of material.

Cross-section B.—To guard against crawfish borings and sipeage, I am now putting in for the "Levee Board" at Vermillion Lake levee 3,000 linear feet of cement wall, ½ inch thick, and extending from high-water line on front slope of levee down through the levee, sloping ¼ to 1, to a depth of 4 feet below the natural surface, which makes the wall in this instance 12 feet in height. Am using 4/15 Louisville cement, 1/15 German Portland, and ⅔ sharp sand, and am keeping an exact account of the cost per square yard as data for future work. c represents an excavation in the front slope for the wall, the material of which is placed in the enlargemen tat d, and e the cement wall. The excavated ditch c is filled and tamped as the wall is filled in. I am satisfied that this will not only keep back crayfish and prevent sipeage, but will give greater strength to the levee by reason of keeping earth dry, and will render clay and buckshot levees safe. To save cost of excavation at c, I am now trying to mature a plan for a machine to be driven by a small engine, constructed somewhat on the order of a pile-driver. In place of the hammer a chisel-shaped blade is to be used to cut the levee longitudinally from the high-water level on front slope to the depth required, say 15 feet, the orifice left by the chisel to be filled with cement-grout.

Cross-section E.—This is an exact cross-section of the Lake Bolivar levee, constructed under my supervision across the head of the lake in 1882.

An effort was made at great cost to build this levee in 1870 upon the natural surface, by the engineer then in charge of the district, but owing to a quicksand foundation the material would sink and spread, and it was found impossible to build up after 15 feet in height was reached.

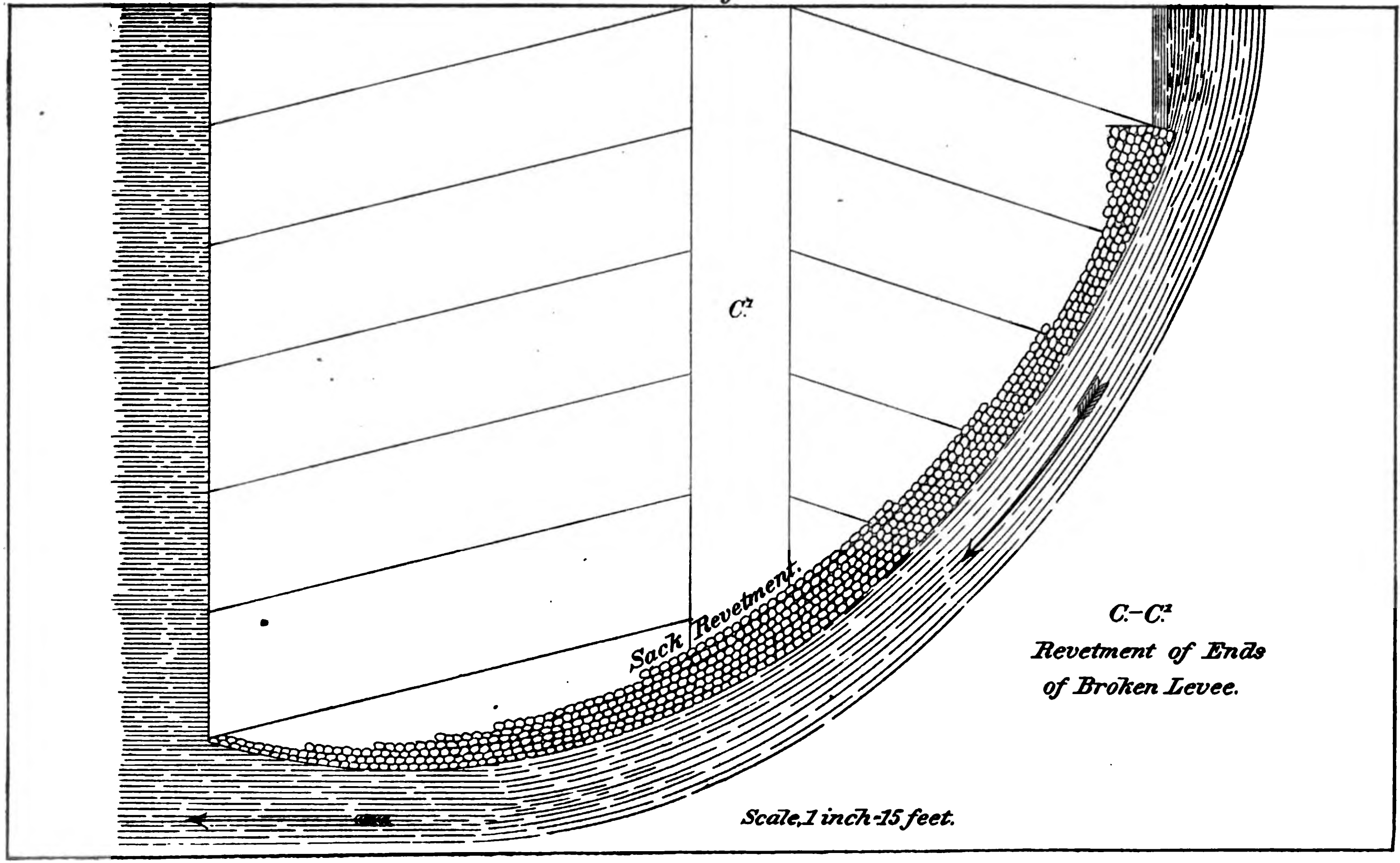
The base had spread six hundred (600) feet in width. A vain effort was kept up, however, to build it to the required height of 22 feet; but little progress was made, and at this time the protection levee broke, water ran over the work and swept it away. In rebuilding this levee I used a mattress foundation, which was constructed by first laying poles, from 6 to 8 inches in diameter, longitudinally, as close as they could be placed, breaking joints, and of sufficient width to extend out to within 60 feet of the slope-stake; then another layer of poles was laid on the top, and at right angles to the first course, breaking joints, and spiked down to first layer at intervals of 5 feet with ship-spikes. Upon the second course a coating of brush 1 foot thick was laid parallel to second course; standards or shrinkage poles were then firmly set in the mattress and secured by spikes, and of sufficient height above grade line to allow for the anticipated depression of mattress, with rings on the poles indicating net and shrinkage grade.

Yazoo Pass levee was built upon similar mattress by M. Meriwether, and the levees crossing the bayous at the head and foot of Lake Bolivar were built by me in 1869 in this way, with success.

Revetment C and C^1.—The ends of levees at crevasses should be secured at the earliest possible moment; work should begin at each end simultaneously. Sacks should be filled with earth, tamped and securely sewed, and if the water should be of greater depth than 3 feet the sacks ought to be threaded in sections upon a three-eighth inch cord, and anchored before throwing them into the swift current. This should be continued until a foundation is formed up to the water line extending from lower end of the levee around the end upon the upper slope from 30 to 60 feet from the end, then carefully place your sacks, breaking joints as in brick work, giving ample batter on the front, and securely sewing each sack as they are laid to those contiguous. This wall should be continued 4 or 5 feet above the water line, in order to get the necessary weight, and provide for undermining of the base which occurs from day to day, rendering constant watching and repairs necessary.

D and *E*.—D shows end view, and E three-fourth front view of a dam constructed upon piling 6″ 6″—14 feet long, driven 7 feet in the ground and 6 feet apart each way, with top of front pile made firm by brace *F* against rear pile where it enters the ground, also as at *G* to make steady, and to support platform for extension of work. Cross-timbers H 12 feet long 2½ by 8 inches should be let down against the piling on the upper side, the first resting edgewise upon the ground, the second about the water line. In

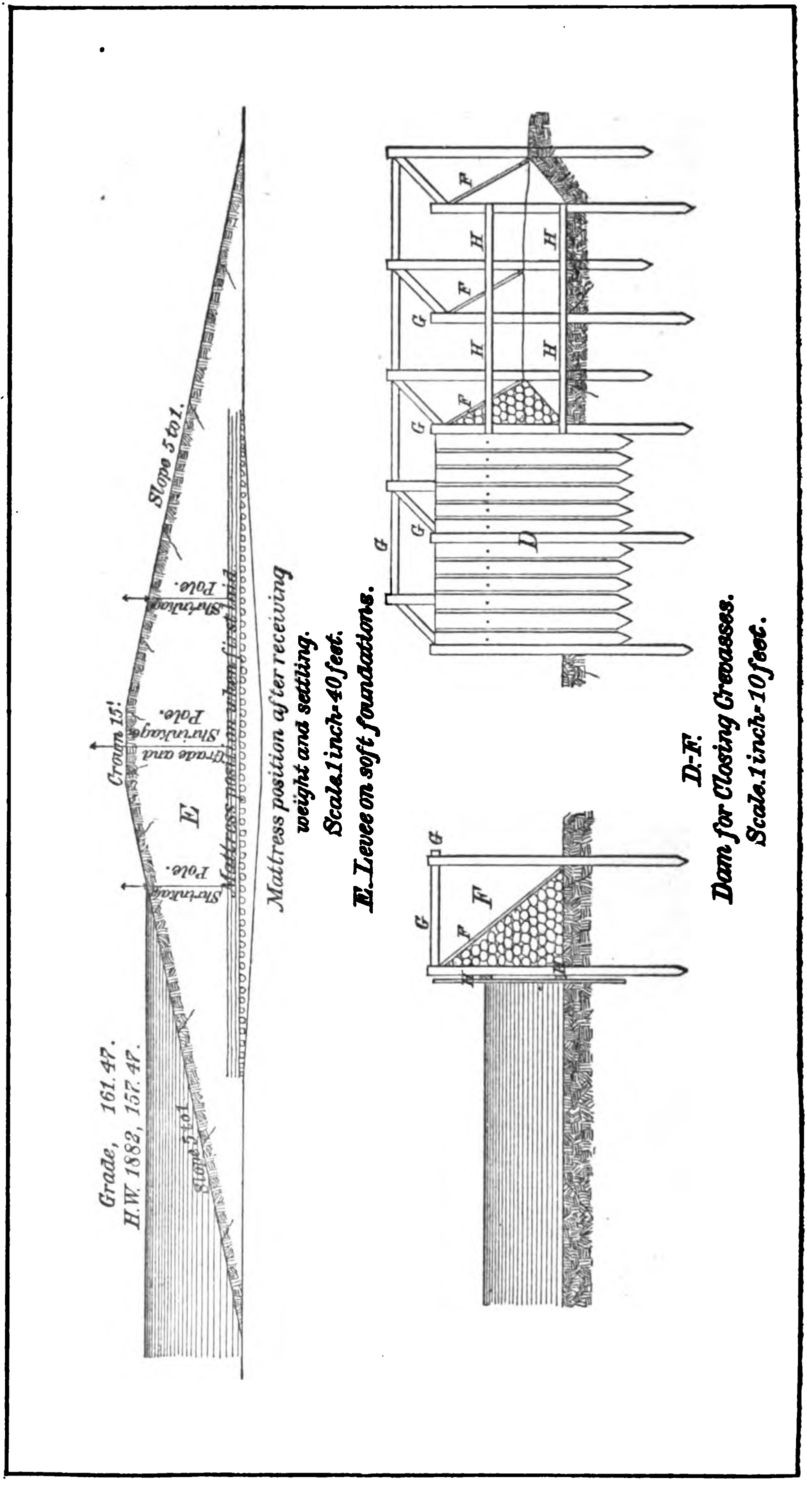
Fig. 2.



C.–C¹
Revetment of Ends of Broken Levee.

Scale, 1 inch-15 feet.

Fig. 3.



Mattress position after receiving weight and settling.

Scale 1 inch-40 feet.

E. Levee on soft foundations.

D-F.

Dam for Closing Crevasses.

Scale 1 inch-10 feet.

front of these is driven sheet piling 9 feet in length, 2½ feet in the ground. After this fill in between brace *F* and the sheet piling with sand-bags, then with earth if you have it.

Very respectfully, your obedient servant,

GEO. M. HELM,
U. S. Asst. Engr.

Capt. W. L. MARSHALL,
Corps of Engineers, U. S. A., Vicksburg, Miss.

L 6.

REPORT OF W. G. BLUNT, ASSISTANT ENGINEER, UPON A SURVEY OF CHOCTAW BEND REACH.

WILSON'S POINT, LA., *February* 7, 1883.

SIR: I have the honor to forward herewith tracings of the map of hydrographic survey of Choctaw Bend Reach, made November 17–December 27, 1882, under your direction.

It was practically a low-water survey, the gauge at Arkansas City reading 8.6 to 13.8 feet, the lowest of the season.

The party arrived at Bolivar, Miss., on the evening of November 16, in tow of the Charlie De Pauw, and work was begun on the next day. Considerable delay was experienced for want of points of connection with old survey by Assistant Engineer Ockerson under Mississippi River Commission in 1881–'82. Most of the points had caved off and all others as far down as Lucca Landing were covered with deposit too deep for removal, except one at Jersey Point. A new system was therefore observed by simple azimuth from a base of 1574^{m} measured with chain on the bar opposite Bolivar, for the purpose of locating range signals and caving banks. These points are shown on the map in capitals, while the old ones are in italics. They are marked on the ground by nail in stake, with tripod and target pole plumbed over it—tripods being 10 to 15 feet high, and well set in ground. Generally, trees are blazed and marked △, in the immediate vicinity.

Ranges for sounding were placed at right angles to trend of river and about five hundred meters apart, beginning with No. 1 at Cork's Point, and ending with No. 73, below elevator at Arkansas City. These ranges were permanently marked by a stake with nail in top on each bank, as far back as seemed economical, projecting from 6 inches to 3 feet above ground, blazed and mark in red chalk, thus: $\overset{\text{T}}{\boxed{\begin{array}{l}\text{24 L}\\ \text{USE}\end{array}}}$ letter L or R being used, as the stake was on left or right bank. (In some cases these marks were left on the face of a tree, instead of driving stakes.) Trees were blazed and marked in the vicinity to show location of permanent mark, and sketches preserved for future reference. The ranges were marked for sounding by a square white-back target near stake on each bank, and a front target of colored flags, to designate numbers of ranges, thus:

1, 6, 11, &c.: 1 white; 2, 7, 12: white over red; 3, 8, 13: 2 white; 4, 9, 14: red over white; 5, 10, 15: white over black.

These were located by azimuths from the new triangulation points.

Soundings were taken from a skiff with sixteen-pound lead, and three-eighths inch cotton line marked in feet, and tested each day. They were located by one sextant angle on range. About every 3 miles a water surface was taken from the Mississippi River Commission bench-marks, which, when the height of 0 on Arkansas City gauge is known, will give slope at time and stage when taken. The soundings, however, were reduced to a stage of 0 on Arkansas City gauge, thus giving minus depths, or heights of bar above that stage, shown in red figures on map. After this reduction, according to your instructions of January 11, water lines were drawn for each 5 feet change of depth (— or +), those at and above 10 feet depth at low water being shown in red, the remainder in blue, with distinguishing marks seen by reference to map.

Under your instructions, no attention was paid to topography other than to locate bank lines where changed since last survey. This was done by sketches between located signals, otherwise topography was transferred from tracings sent from Mississippi River Commission office, which in themselves are rather unreliable from continual use.

The work was plotted to a scale of $\frac{1}{10000}$ on two projections on manila paper, one covering the bend from Cork's Point to Kentucky Landing, about 6 miles, the other from this landing to Arkansas City, 22 miles, the sheets joining on the meridian 91° 07′, and both being north and south with paper. The azimuth system was calculated for plane triangles from the known sides at lower portion of work to check on measured base at Bolivar. These points were then plotted on protractor sheets and transferred to the projection already made of old points, and fitted at upper end by bench-marks located for the purpose.

The map work was done by Messrs. Amelung and Ritchie in conjunction. The placing and location of triangulation points and ranges was done by Mr. Amelung, the soundings by Mr. Ritchie, and the levels by Mr. Pattison, who also acted as recorder for the other gentlemen. To their exertions is principally due the completion of the survey before the rise of river, which began the day after the work closed.

The quarter-boat, in tow of the launch Nellie, returned to Wilson's Point and reported to Mr. Hider for duty on the 30th.

Respectfully submitted.

WM. T. BLUNT,
United States Assistant Engineer.

Capt. W. L. MARSHALL,
Corps of Engineers, U. S. A.

APPENDIX M.

REPORT OF MAJOR AMOS STICKNEY, CORPS OF ENGINEERS, UPON OPERATIONS IN THE FOURTH DISTRICT.

UNITED STATES ENGINEER OFFICE,
No. 3 SOUTH RAMPART STREET,
New Orleans, La., November 20, 1883.

SIR: I have the honor to report as follows on the several works in my charge under the supervision of the commission, from December 1, 1882, to October 31, 1883.

LEVEES.

Since December 1, 1882, work on levees has continued with some interruption by high water in the Mississippi, which in some cases caused a total suspension of work and necessitated the extension of the time for completion of all unfinished levees. Progress has been much slower than was anticipated when contracts were made. This was due to a scarcity of labor last season, and unusual amount of malarial fevers this season, and the bad management of contractors. Repeated notices have been sent to the different contractors whose work progressed slowly with small forces to increase the number of laborers employed, but these notices seem to have had no effect. Up to date six levees have been completed and accepted, leaving five more unfinished. Two of these will probably be completed by the end of the year, and the others, it is hoped, before the floods. There is prospect with the approach of cool weather of the contractors largely increasing their forces and making better progress.

SURVEY OF UNLEVEED FRONT.

Detached surveys have been made at several localities along the line of levees in this district, but no provision has been made yet for construction of the levees. Portions of the lines staked off have not been connected, and others have proved to be too close to the river. With a view of connecting the line of levees to make them continuous, and to establish lines not yet surveyed, parties are now being organized. The following report of Mr. H. S. Douglas, assistant engineer in general charge of levees, gives the details:

NEW ORLEANS, LA., *November* 5, 1883.

SIR: I have the honor to submit the following report on the "construction and repair of levees, fourth district," from December 1, 1882, to October 31, 1883, giving each levee in detail:

TENSAS FRONT.

From Castleman's to Buck Ridge, near Point Pleasant. Total length of embankment, 9,818 feet. Computed contents, 65,661.71 cubic yards. Slopes, 2 and 3 to 1. Crown, from 6 to 8 feet. On December 1 the contractor was at work with a small force, being under the impression that his work would not exceed 30,000 cubic yards; but on December 2 he was notified that his work would be increased, and he was directed to employ additional labor. This he failed to do, and, although an embankment sufficient to resist the water was constructed, the levee was not completed before the rising river came against it. Work was resumed on the subsidence of high water, and the levee was completed and accepted August 6, 1883.

SHIPP'S BAYOU TO HARD TIMES.

Length of embankment, 9,727 feet. Original estimate, about 183,000 cubic yards. Computed contents, liable to increase, 129,613 cubic yards. Slopes, 3 and 2 to 1. Crown, from 5 to 12 feet. Length of protection levee, 1,044 feet. Computed contents, 10,095.33 cubic yards. Slopes, 4 and 2 to 1. Crown, 4 feet. Grade at up-stream end of main levee, 90.895; grade at down-stream end of main levee, 90.695.

The force engaged on this levee was inadequate, and in consequence of the backward condition of the main embankment it was found necessary, February 7, 1883, to order the construction of a protection levee, which, on account of the water coming at once against the fresh earth, was very difficult to maintain. However, it was held, but the caving of the river bank at a point above the main line caused an extensive crevasse in the old levee, and the water rushing into the bed of Lake Saint Joseph, which the main new levee crosses, caused a break in it. The ground to be occupied by the levee was flooded, and after the ends of the new work had been protected to prevent further caving, work was suspended, April 17, 1883, to await a decline in the river. The contractor recommenced work September 13, 1883, and expects to complete the line by December 15.

HARDSCRABBLE AND BONDURANT.

Length of embankment, 33,529 feet. Original estimate, about 330,000 cubic yards. Computed contents, 337,702.85 cubic yards. Slopes, 3 and 2 to 1. Crown, from 6 to 10 feet. Grade at up-stream end, 87.771; grade at down-stream end, 86.871.

The annulment of the original contract was recommended for lack of due diligence on the part of the contractor. The annulment was approved December 2, 1882, and authority given to advertise for new bids by circular letter. Proposals were called for to be opened December 4. The bid of P. J. Kennedy was considered the most favorable, and award recommended to him, which award was approved December 6, 1882, and work commenced by the contractor December 8. About one-third of this levee is located in an open field, in light, sandy land; the balance in a dense swamp, with buck-shot soil. The drainage of this swamp is poor; and although embankment construction proceeded rapidly in the open field, the unfavorable weather and lack of labor made the swamp-work proceed slowly. On February 24, 1883, the river flowed over its banks and through the swamp, flooding the levee-way and contractor's camps, causing a stoppage of the work on that portion of the levee. It was considered impracticable to build a protection levee. Work with a small force has continued with but a slight intermission on the open-field portion of the levee, and during the last month has been resumed in the swamps.

KEMPE BREAKS AND EXTENSION.

Length of embankment, 17,222 feet. Original estimate, about 340,000 cubic yards. Computed contents, 305,110.79 cubic yards. Slopes: breaks, 3 and 2 to 1; extension, 3 and 3 to 1. Crown: breaks 6 to 8 feet; extension, 8 feet. Length of protection levee, 1,862 feet. Lack of an adequate force delayed the completion of this levee, and the construction of a protection levee was ordered.

It was completed February 20, but it afterwards showed signs of being weak, and was raised and strengthened. Work on the main line of embankment was suspended March 17, as the back-water encroached on the levee-way and flooded the contractor's camps. Embankment construction was resumed September 11, and is now in progress. It has been found necessary to change the line of the Kempe extension, as the river bank above the original point of junction with the old levee was caving rapidly. The new line joins the old levee at a point above any probable caving. The present allotment not being sufficient to complete the new line, the State of Louisiana has undertaken to build that portion not constructed by the General Government.

LAKE CONCORDIA BREAKS.

Length of embankment, 92,460.5 feet. Original estimate, about 301,000 cubic yards. Computed contents, 202,724.99 cubic yards. Slopes, 3 and 2 to 1. Crown, from 4 to 13 feet. Grade at up-stream end, 74.195. Grade at down-stream end, 74.136. Work on this long line of light embankment was not interrupted by high water, and proceeded rapidly, labor being plentiful. The levee was finally completed and accepted June 11, 1883.

FROM GREEN'S TO FAIRVIEW.

Length of embankment, 55,410 feet. Original estimate, about 373,000 cubic yards. Computed contents, 385,714.22 cubic yards. Slopes, 3 and 2 to 1. Crown, 4 to 8 feet. Grade of up-stream end, 68.915. Grade of down-stream end, 67.288. Work was pushed rapidly, but the contractors were unable to obtain sufficient force to complete the levee before high water. A light protection levee was thrown up along the river front of the Glasscock swamp, through which the main levee line passes, but on February 20 this gave away and the river poured through an unfinished gap of 2,600 feet in the levee, stopping further work in the swamp until the subsidence of the water. Embankment construction has, however, continued on the upper and lower ends of the levee, and the levee is nearly completed, except the gap of 2,600 feet before mentioned, on which the contractors are now working.

ATCHAFALAYA FRONT (ATCHAFALAYA RIVER TO RED RIVER LANDING).

Length of embankment, 20,708 feet. Original estimate, about 122,000 cubic yards. Slopes, 3 and 2 to 1. Crown, from 4 to 8 feet; Grade at Atchafalaya end, 61.448; grade at Red River Landing end, 59.168. The annulment of the original contract was recommended for lack of due diligence on the part of the contractor, which recommendation was approved December 2, 1882, authority being given to advertise for new bids by circular letter. New proposals were accordingly called for, to be opened December 4. Mr. C. L. Hardeman was the lowest bidder, and award of contract to him was recommended, and approved December 6. Work was commenced December 8, 1882, and would have been completed but for mismanagement on the part of the contractor. However, an embankment sufficient to resist the high water was constructed, and the work was inspected and found short. Contractor was notified to fill out the shortages, and he reported the work completed June 26, 1883. It was inspected, and still found short. The contractor refused to do any further work, but has since concluded that he would, and is now engaged in completing the levee.

HOG POINT TO RACCOURCI (OLD RIVER).

Length of embankment, 16,460 feet. Original estimate, about 74,000 cubic yards. Computed contents, 65,946.19 cubic yards. Slopes, 3 and 2 to 1. Crown, from 4 to 8 feet. Grade at up-stream end, 59.003. Grade at down-stream end, 58.103. Work proceeded without incident until date of completion and acceptance, March 27, 1883.

RACCOURCI CREVASSES.

Length of embankment, 5,668 feet. Original estimate, about 84,000 cubic yards. Computed contents, 71,221.77 cubic yards. Slopes, 3 and 2 to 1. Crown, 8 feet. Grade throughout, 56,026. Embankment construction at first proceeded rapidly, and it was reported completed March 12, 1883, but upon inspection was found short. Contractor was notified to fill out the shortages, but it was not until July 28, 1883, that the work was finally completed and accepted.

STEWART'S CREVASSE.

Length of embankment, 1,674 feet. Original estimate, about 9,000 cubic yards. Computed contents, 9,175.55 cubic yards. Slopes, 3 and 2 to 1. Crown, 6 feet. Grade at up-stream end, 52.411. Grade at down-stream end, 52.311. Work was not commenced by the contractor until December 18, 1882, and the force employed was so small that the levee was not completed until March 20, 1883. It was inspected and received April 13, 1883.

POINT COUPÉE CREVASSE.

Length of embankment, 5,762.5 feet. Original estimate, about 120,000 cubic yards. Computed contents, 110,947.01 cubic yards. Slopes, 3 and 3 to 1. Crown, 8 feet. Grade throughout, 50,815. Owing to the neglect of the contractor to put a sufficient force on this work, it was in a very precarious condition about February 1. The river was rising rapidly and threatened to pour through the unfinished levee. The employment of convict labor was authorized, and a large force put to work. The base of the levee was put in, and the balance of the embankment built up with earth from the land side to keep ahead of the rapidly rising river, which came against the unfinished levee February 20. A certain portion of the levee kept sinking or settling. This was where the line crossed an old lake-bed or slough. It being difficult, if not impossible, to measure the amount of earth in this portion, a modification of the original contract, so far as this part of the levee was concerned, was recommended, and approved April 25, 1883. The levee was inspected and received May 31, 1883. The principal causes of the non-completion of work have been:

First, The lateness of the season when work was commenced, and the early and sudden rise in the Mississippi River.

Second, The difficulty in obtaining and holding labor. The large amount of railroad work going on throughout the country, in addition to the levee work, insured employment to every able-bodied man who desired it, and as a consequence labor was very unreliable, going from levee to levee without apparent cause. I have reason to believe that upwards of 5,000 men were brought to the various levees, and at no time were more than half that number actually employed. The contractors were notified from time to time to increase their forces, but these notifications seemed to have but little, if any, effect.

Third. But few of the contractors personally superintended their work, preferring to trust to employés, who were in many cases inefficient, and had no disposition to push the work to completion.

The principles generally observed in establishing the grades, crown, and slopes of the levees in the district have been to build them at least as high as the old levees which they join. The grades given in this report are from the bench marks of the Commission referred to a plane 190.84 feet below the zero of the United States Engineers' gauge at Memphis, Tenn. The slopes have been governed by the amount of money allotted. Only two of the levees have been built with 3 and 3 to 1 slopes; the remaining nine have 3 and 2 to 1 slopes. In most cases an endeavor has been made to make the crown equal to the height to the nearest foot where the height was greater than 4 feet. Where a line of light embankment crossed a slough or bayou the crown of the levee was increased, or a banquette, so termed, built on the land side, to within the width of the crown of the top of the levee. Levees with 3 and 3 to 1 slopes were built with a uniform crown of 8 feet.

In future it is not thought advisable to build levees where the fill is more than 6 feet with less than 3 to 1 slopes, especially in swampy localities. Flumes, culverts, and other openings through the embankments have not been permitted in any case, and should not be. Measures should be taken to prevent the levees being used as roads, or else they should be built considerably higher than would otherwise be necessary, to allow for the wearing down caused by traffic. A portion of the levees designated as, "from Castleman's to Buck Ridge," in the advertisement for proposals, was surveyed and staked off, but was not built for lack of funds. It is probable that the high water of 1883 may have obliterated some of the line and caused the banks of the river to cave so as to render a change of line advisable at certain points. A resurvey will be necessary between Castleman's and New Carthage to determine these facts. The Bougiére Crevasse was also staked off, but the assistant engineer who made the survey states that the line is probably too close to the river, and it should be changed. From Fairview, the lower end of the "Greens to Fairview" levee to the mouth of Red River, in which is included the Bougiére Crevasse, is unleveed except isolated pieces on the high lands. The distance by river is 54 miles, and a survey of this stretch will be necessary before work is undertaken. The above surveys and the works based upon them will make the line of levees continuous on the right bank of the river throughout the district to the forts. I have been assisted in the field-work by three assistant engineers acting as inspectors, and thirteen sub-inspectors. This force has been reduced from time to time as the levees were completed or put in such a condition as to no longer require close supervision.

Summary.

Levees.	Total length embankment.	Length of embankment constructed.	Computed contents of levee.	Levee October 31, 1883.
	Feet.	*Feet.*	*Cubic yards.*	*Cub. yds.*
From Castleman's to Buck Ridge, near Point Pleasant	9,818.0	9,818.0	65,661.71	65,661.71
Shipps' Bayou to Hard Times, including protection levee	10,771.0	6,669.0	139,708.39	76,416.36
Hardscrabble and Bondurant	33,529.0	15,653.0	337,702.85	105,383.45
Kempe Breaks and extension, including protection levee	19,084.0	13,862.0	305,110.79	172,476.05
Lake Concordia Breaks	92,460.5	92,460.5	202,724.99	202,724.99
From Green's to Fairview	55,410.0	52,801.0	385,714.22	318,384.46
Atchafalaya River to Red River Landing	20,708.0	20,708.0	70,377.57	59,028.47
Hog Point to Raccourci (Old River)	16,460.0	16,460.0	65,946.19	65,946.19
Raccourci Crevasses	5,668.0	5,668.0	71,221.77	71,221.77
Stewart's Crevasse	1,674.0	1,674.0	9,175.55	9,175.55
Pointe Coupée Crevasse	5,762.5	5,762.5	110,947.01	110,947.01
	271,345.0	241,536.0	1,764,291.04	1,257,366.01

UNLEVEED FRONTS.

	Estimated length.	Estimated cubic yards.
	Feet.	
Castleman's to New Carthage	50,000	410,000
Bougiére	23,400	687,000
Black Hawk to Red River	88,500	

Timber felled on all levee lines, 260 acres.
Total length of levees under contract, 51 miles, 2,065 feet.
Length constructed to October 31, 45 miles, 3,936 feet.
Remaining to build, 5 miles, 3,409 feet.

	Feet.
Total contents of levees as computed	1,764,291.04
In embankment October 31	1,257,366.01
Remaining to place in embankment	506,925.03

Very respectfully, your obedient servant,

H. S. DOUGLAS,
Assistant Engineer.

Maj. AMOS STICKNEY,
Corps of Engineers, U. S. A.

IMPROVING MISSISSIPPI RIVER AT NATCHEZ AND VIDALIA.

No work has been done since the transfer of this work to me by Capt. A. M. Miller, Corps of Engineers, U. S. A. It had been my expectation to have an examination made of this locality during low water, for the purpose of preparing a project for work, but the unusual sickliness of the season has so crippled my force of assistants that nothing has been done. The old survey shows the principal features of the locality, and I expect to base a project upon that survey. A recent general view of the banks obtained in passing on a steamer shows that the caving of the banks continues as before, but only to a small extent in Giles Bend, the worst caving being in Marengo Bend and down toward Waverly Point. The danger to Natchez Harbor is not immediate; but works for bank protection will be required to prevent the working down of the bend above Natchez.

IMPROVING MOUTH OF RED RIVER.

At the date of my last annual report to the Commission work in old river and at the mouth of Red River was suspended, as high water made it no longer necessary for navigation.

In letter of August 17, 1883, to the president of the Commission, I recommended to the Commission that, if necessary to keep open navigation during low water, the same means be employed as heretofore, that is, by moving a stern-wheel steamboat attached to two tugs backward and forward over the shoal places to stir up the mud, so that the current might cut a channel, and to use a dredge-boat for cutting a channel through the bar at the mouth of old river. This having been approved by the Commission, steps were taken August 25, 1883, to procure the necessary plant.

This plant should have been at work by September 3, 1883, but on account of breakage of machinery of one of the tugs after starting from New Orleans, and the sinking of the barge containing the supply of coal, actual operations were not commenced till September 7. At this time there was 9 feet of water on the outer bar and 5 feet through what is known as the "gut" in Old River, and it was thought that a channel could be maintained; but the water continued to fall with great rapidity, and the banks, from 800 to 1,000 feet, through the gut, slid in, almost completely closing the water-way and shutting off the flow. The consequence of this was an immediate draining of Lower Old River into the Atchafalaya from a point about a mile above the foot of Turnbull's Island, leaving the boats hard aground, two of them having scarcely any water around them.

I visited the locality October 11, and found at one place a width of about 3 feet, with less than 1 foot depth, which was all that remained of the river. This sliding in of the banks has occurred at each low-water season for a number of years, but never before to the extent of this year.

Some harsh comments have been made, as in previous years, with regard to the failure of the plant to keep a navigable channel, but such comments must certainly have emanated from persons much interested in keeping navigation open, but ignorant of the cause, or extent of the cause, which operated to close the channel. It has never been claimed that the plant used could do anything more than help the current in deepening the shoal places, when the water was low enough for the action of the tug wheels to be felt on the bottom and the volume of water and current strong enough to carry off the material stirred up. The dams formed by the sliding in of hundreds of feet of the river banks not only cut off the necessary water to float the boats, but stopped the current necessary to carry away any material that might have been stirred up. This peculiar sliding in of the banks in this locality has, I believe, never been satisfactorily explained. Upon my recent visit I made a special investigation of the matter, and I believe I have discovered the cause of the instability of the banks to be the presence of water back of the banks, whose surface is at a considerable elevation above the river. When the river falls rapidly this back water, acting under a considerable head, forces its way under the banks, converting the lower strata into a semi-liquid material which will not stand under a slope of 1 in 20, or even flatter. I believe there was not a single instance of sliding bank behind which I did not find either standing water or pools where water had recently been. The natural drains for this back water are each year more and more obstructed by the deposit of sediment from overflows, the obstruction increasing more rapidly near the river banks. As a result of this the pond water is held at a higher level, and when the river is low forces its way through the soil under greater head.

The steamboat and tugs commenced work September 7, and were compelled to stop September 25. They resumed work on October 17, and on November 10 were ordered to return to New Orleans, there being a navigable channel 8 feet deep through Old River. The dredge commenced work on the outer bar September 8, and worked continuously until October 22, when she was moved up to the gut. On the 10th of November she was laid off. I am at present engaged upon a plan for the permanent improvement of this locality, which I hope to present to the Commission in a short time. In December, 1882, an assistant engineer was sent to make some surveys of Old River in order to obtain data for estimates and project for placing a sill across old river, with a levee across the valley to check the enlargement of the passage into the Atchafalaya River. This was completed early in February, and estimates were submitted to the Commission March 20, 1883. The Commission decided to postpone action on this. Upon my recommendation for a resurvey of the old river, which was approved by the Commission, a party was started from New Orleans, June 5, and work commenced a few days afterwards, but sickness and unfavorable weather at times almost suspended operations. The survey is still in progress, and it is hoped that the present cool weather will enable the party to complete it soon. The following report of the assistant engineer in charge gives the details:

RED RIVER LANDING, *October* 31, 1883.

MAJOR: I have the honor to report to you the amount of work accomplished on the survey of the mouth of Red River and vicinity since the 7th of June, when I arrived here with a portion of my party, which was not complete until the arrival of the steam-launch on the 22d of June. The survey of the Mississippi, including both banks, is finished from below Red River Landing to Carr's Point, by means of a shore line on the right bank and distances carefully measured to the top of the bank, so as to show the erosion accurately, and a note of the stage of water and its line at the edge. The opposite bank is located by a series of angles taken on flag stations placed on all points and inlets, so as to define the line of the top of the bank correctly. The sides of triangulation on the right bank forming the bases are never less than half a mile in length, and a primary base has been carefully measured and checked with a steel-tape measure. Observations of the true meridian have been taken on this base line. A traverse line with the immediate topography has been run on the levee from half a mile below Red River Landing to section No. 12, on Atchafalaya River. Cross-sections Nos. 2, 4, 6, 10, and 12 of the Atchafalaya have been relocated, sounded, plotted, and sent into the office. Likewise in the lower old river, cross-sections F, G, I, Z, X, also D, V, and H, in the mouth, near the Mississippi. These sections require to be extended back on the high ground on the right of the Atchafalaya, and on the Turnbull Island side of Lower Old River, now that the water is low enough to make it practicable to do so. Eight cross-sections have been taken on the upper old river at right angles to the bed of the river, and extending across all the chutes to the high ground on either side, and the notes with approximate location on the map of 1879 have been sent to the office. A section and the low-water discharge of Red River have been taken 1,000 feet above the head of Turnbull's Island, plotted, and sent in. The time of observation was most favorable; if we had not had such difficulty in getting to the Point, the section would have been extended further, and the observation made more elaborately. The surface fall to Barbre's at the time of observation will be forwarded to you with the notes of cross-section No. VIII of Upper Old River. The shore line on Lower Old River has been run Section L near Ash Cabin, connecting and locating the cross-sections. The instrumental work, measuring, sounding, relocating, and referencing off on the cross-sections has been done in a careful and accurate manner. The levels check most satisfactorily with those of Mr. Reese in 1880. The direction and approximate velocity of the current in Old River has been daily observed and the report for the last ten days is inclosed, also a sick list for each month, taken from a rough record of each day's work.

There are many odd days and half days where men were off duty that I took no note of, and the amount of days lost by sickness fails to express how the general ill-health of the party has retarded the survey, and the enervation of the whole party caused by the sickliness of the season. The deaths of the old inhabitants in this locality have been remarkably numerous. The sickness of two members of my party has resulted in death soon after leaving the party. Both were only a short time employed. The character of the malaria is tenacious and malignant. Mr. Struthers, a leveler, who left August 12, and went by sea to New York, writes to me on October 12 that he is still very weak and subject to fevers, and has been unable to do any work since he left here. Mr. Postell, a rodman, writes from Georgia to the same effect. The organization of my party is continually spoilt by the changes in its members. By comparing the time lost by sickness with the time on the pay-rolls, a percentage of time lost can be obtained.

The greatest surface fall with running water between the Mississippi that I have knowledge of was on the 21st of October, and was 6.′4.

I am, respectfully, your obedient servant,

ARTHUR OWEN WILSON,
Assistant Engineer.

Maj. AMOS STICKNEY,
Corps of Engineers, U. S. A.

In accordance with the resolution of the Commission of September 14, 1882, and my project presented to the Commission March 20, 1883, an assistant engineer and party was sent into the field in June, 1883, to make a survey to obtain more data for plan and estimate of cost of opening a navigable route from the Mississippi River to the Atchafalaya and Red River by way of Bayou Plaquemine. Work was commenced June 13, but sickness and bad weather made progress very slow. The party became disorganized on June 28, and the assistant engineer returned to New Orleans sick. Another assistant was sent up, but after a few weeks of slow work became sick and died. The survey was suspended September 11. It will be resumed as soon as practicable. An estimate of the cost of the Plaquemine route is being prepared from the notes of the recent survey in Bayou Plaquemine, and from a previous survey of Grand River made under the direction of this office.

SURVEY OF CUBITT'S GAP.

A party was sent to make this survey on January 13, 1883, but owing to dense fogs nothing was accomplished beyond making a few soundings across the river and a few in the gap. The survey was suspended and the party returned to New Orleans. After the cessation of fogs the river was too high, being over its banks, to permit a party to camp in the vicinity. This present time is favorable for the survey and a party will probably be sent to the locality during this month. An additional allotment is necessary for this, the original allotment having been too small and a considerable portion used in the ineffectual attempt. Captain Heuer, Corps of Engineers, has kindly offered to make the soundings in the river, with the party constantly engaged at the jetties, who are accustomed to deep-water soundings and have a steam-launch at their disposal.

OBSERVATIONS AT CARROLLTON.

In order to carry out the resolution of the Commission, allotment for which was made November 19, 1882, and afterwards increased by $1,500, an observation party was stationed at Carrollton on January 17, 1883, and measurements of river discharge were commenced on January 27, 1883. Daily observations were made when the weather would permit until the latter part of July. At this time it was found that by using the party in connection with the preparatory work for improvement of New Orleans Harbor a longer time could be covered. The observations were therefore reduced to two per week and continued till September 7, when the allotment was exhausted. The report of Assistant Engineer W. G. Price gives details of the observations (see plates II and III):

CARROLLTON, LA., *November* 8, 1883.

MAJOR: I have the honor to submit the following report of discharge measurements of the Mississippi River at Carrollton, La., from January 27 to September 7, 1883, made under your direction. The party was organized in Saint Louis, and arrived in Carrollton January 17. It consisted of an assistant engineer, a recorder, an engineer of launch, a steersman, and two boatmen. Ten days were required to construct the necessary apparatus, and the first discharge was measured on January 27. The discharges were taken daily, except Sundays, from January 27 to July 21, and then in order to make the appropriation last until low water the discharge was measured only twice a week. On September 7, the appropriation having been about used up, the work was stopped. The section used is known as the Cambronne section. The velocity was measured with the current meter; meters A and B of my own construction were used. The meter was run from a catamaran which was lashed to the side of a steam-launch, which was kept steady at the velocity stations by the pilot and engineer. Range lines were put up on shore for that purpose. The soundings and velocity stations were located by means of a sextant set at an angle of 14° 2′, and a stadia base-line of signals on shore, the distance being read directly from the base-line. Most of the soundings were taken with an ordinary lead-line, some with a jack chain and others with a graduated wire. As all these soundings agree, it is thought the error from using a lead-line is very small. In taking discharge the velocity was measured at mid-depth only and at eighteen stations. These stations were taken at the same points each day and were near together where the horizontal curve of velocity was sharp and farther apart at other places. The mid-depth velocity was reduced in computing the discharge by from 3½ to 4 per cent., which quantities were determined from the vertical curves of velocity. The method of partial areas was used in computing. The eighteen velocity stations divided the section into nineteen partial areas, and each area except those next the shore was multiplied by the mean of two velocities. The apparatus used worked very nicely; the meters were rated several times during the work and always with the same result.

VERTICAL VELOCITY CURVES.

These curves were measured with the current-meter at points from 1 to 5 feet apart from the surface to within 1.3 feet of the bottom. The meter was run from ten to twenty minutes at mid-depth and two minutes at each of the other points. The verticals were measured at each of the eighteen velocity stations used in measuring discharge. The curves were plotted on cross-section paper, and then the depth was divided into thirty parts, and the velocity was scaled at each depth. To combine them the velocities at the same proportional depths in the different curves were added and the resulting curve plotted. To get the mean velocity the area of the curve was divided by the depth. I have made four combinations of these curves taken between January 27 and July 1. Those taken between July 1 and September 7 have been combined in one curve. These curves are very regular, and show that the wind has but little effect on the motion of the water, and that the average per cent. of mean velocity to mid-depth velocity is about 96½, being a little less for a rising river and a little more for a falling river.

BEND SOUNDINGS.

I began sounding a section across Nine Mile Point Bend March 20, and these soundings were continued at intervals till September 7. The soundings have been plotted and the datum areas calculated. They show that the bottom cut out as the river rose and that it filled up again at low water.

AMOUNT OF WORK DONE.

Discharges measured	148
Vertical velocity curves measured	61
Section in bend sounded	8 times.

Respectfully submitted.

W. G. PRICE,
Assistant Engineer.

Maj. AMOS STICKNEY,
Corps of Engineers, U. S. A.

Tabulated results of discharge measurements.

Date.	Gauge.	Water width.	Water area.	Datum area.	Mean velocity per second.	Discharge per second.
1883.			*Sq. feet.*	*Sq. feet.**	*Feet.*	*Cub. feet.*
January 27	4.609	2,289	147,596	137,236	2.830	417,696
January 30	4.970	2,290	148,642	137,448	2.994	445,040
January 31	5.310	2,290	149,784	137,766	3.008	450,491
February 1	5.630	2,291	152,046	139,061	3.028	460,400
February 2	6.170	2,292	153,062	139,181	3.249	496,277
February 5	7.634	2,300	157,266	139,826	3.820	600,773
February 7	8.494	2,329	159,190	139,228	4.133	657,946
February 8	8.738	2,340	159,668	139,614	4.070	649,867
February 9	8.989	2,342	160,362	139,837	4.198	673,143
February 10	9.230	2,348	161,014	140,051	4.219	679,416
February 13	9.485	2,355	162,122	140,517	4.190	679,299
February 15	9.915	2,355	161,230	138,612	4.269	688,313
February 17	10.385	2,360	162,212	138,566	4.705	763,283
February 19	10.980	2,362	162,736	137,501	4.823	784,872
February 20	11.075	2,364	163,014	137,424	4.833	787,867
February 21	11.165	2,366	162,862	137,107	4.962	808,269
February 22	11,340	2,420	164,376	138,275	4.922	809,171
February 23	11.680	2,518	165,012	137,506	5.172	852,322
February 28	12.151	2,520	165,492	136,892	5.143	849,572
March 1	12.330	2,546	164,848	135,733	5.159	850,563
March 2	12.377	2,546	164,926	136,151	5.268	868,758
March 3	12.298	2,550	165,486	136,627	5.338	883,008
March 5	12.490	2,555	165,976	137,301	5.467	907,516
March 7	12.685	2,560	163,498	133,140	5.551	907,617
March 9	12.952	2,567	164,686	133,891	5,688	936,838
March 12	12.785	2,567	158,542	128,171	5.631	892,798
March 13	12.875	2,567	158,623	128,240	5.571	883,610
March 14	12.940	2,567	160,700	130,022	5.670	911,148
March 15	13.045	2,567	161,146	130,152	5.743	925,400
March 16	13.102	2,567	162,386	131,267	5.670	919,870
March 17	13.175	2,567	162,664	131,384	5.644	918,104
March 19	13.317	2,567	162,426	131,570	5.702	926,298
March 20	13.492	2,567	162,838	131,560	5.818	947,384
March 21	13.452	2,567	164,040	132,640	5.834	957,148
March 22	13.300	2,567	163,658	132,594	5.837	954,264
March 23	13.468	2,567	163,280	132,000	5.849	955,073
March 24	13.910	2,567	164,422	132,170	5.854	962,648
March 26	13.991	2,567	159,410	126,802	6.218	991,208
March 28	14.120	2,567	159,726	126,832	6.199	990,209
March 29	14.264	2,567	160,132	126,879	6.154	985,436
March 30	14.560	2,567	164,784	131,055	6.107	1,006,298
March 31	14.675	2,567	165,070	131,087	6.123	1,010,804
April 2	14.839	2,567	167,010	132,141	6.220	1,038,916
April 3	14.945	2,568	167,244	132,142	6.175	1,032,684
April 4	15.007	2,568	170,620	135,452	6.066	1,035,006
April 5	15.082	2,568	171,810	136,871	6.078	1,047,316
April 6	15.138	2,568	173,082	137,923	5.970	1,033,775
April 7	15.388	2,568	173,487	137,772	6.219	1,079,029
April 9	15.465	2,568	174,694	138,428	5.982	1,044,968
April 10	15.260	2,568	174,195	138,475	6.005	1,046,185
April 11	15.123	2,568	175,870	141,030	5.823	1,024,197
April 12	15.103	2,568	178,080	142,814	5.800	1,032,926
April 14	15.061	2,568	183,272	147,936	5.621	1,030,189
April 16	14.808	2,568	179,526	144,930	5.583	1,002,229
April 17	14.689	2,567	184,212	149,886	5.554	1,023,059
April 18	14.610	2,567	184,123	149,972	5.538	1,019,815
April 19	14.564	2,567	181,130	146,998	5.507	997,583
April 20	14.580	2,567	182,189	148,021	5.469	996,449
April 21	14.500	2.567	180,716	146,607	5.315	960,591
April 23	14.487	2,567	180,689	146,609	5.397	975,098
April 24	14.420	2,567	179,468	145,724	5.336	957,666
April 25	14.335	2,567	179,407	145,795	5.346	959,061
April 26	14.223	2,567	180,031	147,023	5.313	956,671
April 27	14.300	2,567	180,123	146,946	5.320	958,195
April 28	14.201	2,567	179,579	146,619	5.414	972,423
April 30	14.213	2,567	178,714	145,655	5.361	958,189
May 1	14.238	2,567	178,608	145,378	5.260	939,569
May 2	14.234	2,567	178,606	145,378	5.258	940,083
May 3	14.245	2,567	179,716	146,338	5.263	945,836
May 4	14.190	2,567	179,569	146,832	5.256	943,943
May 5	14.268	2,567	179,774	146,337	5.255	945,625
May 7	14.130	2,567	178,888	145,251	5.267	939,483
May 8	14.014	2,567	178,192	145,358	5.309	946,068

* Below zero of Carrollton gauge.

Tabulated results of discharge measurements—Continued.

Date.	Gauge.	Water width.	Water area.	Datum area.	Mean velocity per second.	Discharge per second.
1883.			*Sq. feet.*	*Sq. feet.*	*Feet.*	*Cub. feet.*
May 9	14.076	2,567	176,076	143,165	5.323	936,487
May 10	14.114	2,567	176,232	143,224	5.395	950,759
May 11	14.151	2,567	176,968	143,560	5.285	935,237
May 12	14.076	2,567	176,788	143,564	5.364	948,441
May 14	14.138	2,567	174,048	149,930	5.363	933,882
May 15	14.003	2,567	174,190	141,431	5.344	930,617
May 16	14.085	2,567	174,894	142,985	5.320	929,697
May 17	14.082	2,567	174,991	142,201	5.243	917,341
May 18	14.171	2,567	175,185	142,174	5.168	907,610
May 19	14.206	2,567	175,278	142,169	5.180	908,054
May 21	14.144	2,567	178,080	145,181	5.115	911,026
May 22	14.058	2,567	177,852	145,174	5.206	916,277
May 23	13.948	2,567	181,829	147,465	5.006	910,271
May 24	13.797	2,567	181,430	149,154	5.020	910,977
May 25	13.719	2,567	182,852	150,728	4.947	904,655
May 26	13.854	2,567	183,190	150,719	4.958	908,261
May 28	13.585	2,567	181,256	149,424	4.928	893,233
May 29	13.688	2,567	181,512	149,423	4.867	883,564
May 30	13.686	2,567	183,050	151,182	4.829	883,848
May 31	13.728	2,561	183,432	151,461	4.816	883,430
June 1	13.625	2,467	180,657	149,059	4.853	876,705
June 2	13.507	2,467	180,879	149,072	4.802	864,043
June 4	13.475	2,467	178,299	147,949	4.941	881,062
June 5	13.484	2,467	182,872	151,006	4,818	877,793
June 6	13.436	2,467	182,257	151,010	4.785	873,108
June 7	13.328	2,467	181,707	151,150	4.816	875,085
June 8	13.316	2,467	181,607	151,050	4.741	861,535
June 9	13.288	2,467	181,645	151,154	4.729	859,046
June 11	13.178	2,417	183,510	153,891	4.714	865,049
June 12	13.135	2,417	183,494	153,474	4.660	855,025
June 13	13.076	2,417	183,586	153,680	4.644	852,517
June 14	13.030	2,417	183,471	153,567	4.654	854,066
June 15	12.934	2,417	183,354	153,969	4.700	862,242
June 16	12.900	2,417	183,276	153,869	4.618	846,443
June 18	12.777	2,417	182,130	152,776	4.557	830,027
June 19	12.765	2,417	182,117	152,790	4.596	837,076
June 20	12.705	2,417	180,701	151,627	4.549	822,061
June 21	12.682	2,417	180,534	151,526	4.573	825,601
June 22	12.640	2,417	180,011	150,973	4.573	823,473
June 23	12.454	2,417	179,615	150,998	4.582	821,731
June 25	12.535	2,417	179,034	150,530	4.565	817,328
June 26	12.552	2,417	179,110	150,644	4.627	828,857
June 27	12.496	2,417	180,465	151,986	4.591	828,430
June 28	12.443	2,417	180,344	151,935	4.605	830,559
June 29	12.541	2,392	184,820	157,058	4.572	845,967
June 30	12.554	2,392	184,820	157,027	4.498	831,456
July 2	12.522	2,392	181,524	153,932	4,582	831,545
July 3	12.462	2,392	181,592	154,143	4.597	833,850
July 5	12.374	2,392	181,282	152,902	4.510	817,685
July 6	12.450	2,392	181,452	152,903	4.462	809,572
July 7	12.426	2,392	181,396	152,901	4.548	824,968
July 9	12.480	2,392	180,871	152,296	4.440	803,139
July 10	12.500	2,392	180,871	152,300	4.460	807,760
July 11	12.540	2,397	179,840	151,156	4.558	819,806
July 13	12.590	2,397	181,136	152,260	4.565	827,128
July 14	12.559	2,397	181,020	152,260	4.760	833,749
July 16	12.565	2,407	182,900	154,411	4.519	826,540
July 17	12.455	2,407	182,418	154,110	4.442	810,275
July 18	12.455	2,392	182,428	154,120	4.123	751,289
July 19	12.350	2,392	181,240	152,992	4.123	747,378
July 20	12.345	2,392	181,240	152,992	4.192	801,590
July 21	12.280	2,392	180,562	152,572	4.421	798,279
July 25	11.700	2,387	179,362	152,875	4.329	776,637
July 28	11.455	2,387	178,200	152,540	4.119	733,985
July 31	11.150	2,367	175,896	150,652	4.292	755,190
August 4	9.847	2,337	172,390	150,014	3.790	646,588
August 8	8.520	2,317	167,950	148,842	3.405	571,868
August 11	7.850	2,310	164,860	148,195	3.330	549,111
August 15	6.570	2,300	162,155	145,850	3.126	506,849
August 18	6.120	2,282	161,220	147,429	2.966	478,359
August 22	5.300	2,304	159,830	147,783	2.592	414,350
August 25	4.752	2,192	158,940	148,183	2.582	412,967
August 29	2.875	2,240	154,680	145,090	2.312	357,737
September 7	1.930	2,189	150,832	146,321	1.976	298,124

Tabulated results of vertical velocity measurements.

Depth.	First. Combination of 12 verticals. Wind down stream—velocity.	Second. Combination of 16 verticals. Wind up stream—velocity.	Third. Combination of 8 verticals. Rising river—velocity.	Fourth. Combination of 33 verticals. A mean of all to July 1—velocity.	Fifth. Combination of 21 verticals taken from July 1 to September 7—velocity.
Surface	5.34	5.72	5.96	5.49	2.73
1-30	5.38	5.80	6.05	5.53	2.73
2-30	5.42	5.82	6.09	5.62	2.75
3-30	5.42	5.80	6.09	5.60	2.75
4-30	5.44	5.81	6.09	5.61	2.73
5-30	5.42	5.79	6.09	5.59	2.70
6-30	5.44	5.79	6.14	5.60	2.75
7-30	5.48	5.78	6.18	5.61	2.73
8-30	5.45	5.80	6.16	5.63	2.77
9-30	5.48	5.82	6.18	5.62	2.75
10-30	5.44	5.81	6.18	5.63	2.73
11-30	5.44	5.78	6.16	5.60	2.71
12-30	5.48	5.75	6.18	5.60	2.68
13-30	5.44	5.78	6.21	5.59	2.68
14-30	5.43	5.76	6.18	5.58	2.70
15-30	5.42	5.74	6.12	5.55	2.68
16-30	5.42	5.78	6.17	5.53	2.63
17-30	5.38	5.79	6.09	5.55	2.60
18-30	5.36	5.76	6.08	5.53	2.59
19-30	5.36	5.78	5.98	5.51	2.57
20-30	5.29	5.69	5.98	5.45	2.53
21-30	5.28	5.67	5.98	5.43	2.50
22-30	5.27	5.61	5.94	5.40	2.49
23-30	5.16	5.59	5.88	5.39	2.47
24-30	5.10	5.48	5.79	5.24	2.44
25-30	4.91	5.31	5.65	5.07	2.28
26-30	4.74	5.17	5.50	4.88	2.13
27-30	4.66	4.92	5.28	4.70	2.04
28-30	4.34	4.56	4.98	4.36	1.91
29-30	3.94	4.13	4.36	3.96	1.74
29½-30	3.72	3.65	4.07	3.82	1.57
Bottom	3.05	3.05	3.64	3.07	1.35
Mean velocity	5.200	5.548	5.877	5.344	2.540
Mid-depth velocity	5.420	5.750	6.160	5.550	2.630
Percent of mean to mid-depth	96.29	96.48	95.71	96.29	96.58

Tabulated results of soundings in Nine Mile Point Bend, 1883.

Date.	Gauge.	Datum areas.
		Square feet.
March 20	13.5	177,940
March 27	14.2	186,016
April 16	14.8	189,000
May 3	14.2	186,640
May 23	13.9	189,156
June 5	13.4	184,200
June 26	12.5	196,733
September 7	2.0	156,730

BONNET CARRÉ CREVASSE.

On December 20, 1882, the Commission passed a resolution recommending an allotment of $15,000 for the closing of this crevasse. The allotment was made. The State of Louisiana subscribed $15,000 and private parties about $5,000. Under these conditions the New Orleans and Mississippi Valley Railroad Company concluded to build the levee. An agreement was entered into with John A. Grant, vice-president of the company, for the payment to him of $15,000, less the necessary expenses of inspection and acceptance on completion of the levee, for the entire closure of the crevasse. Upon report of completion an inspection was made of the levee February 15, 1883; and it being found a good, substantial work, payment was made February 22, 1883. Considerable work on this levee was found necessary after its completion and during the flood. This was paid for by the railroad company and the levee maintained in good order. The closure of this crevasse has already had a remarkable effect in deepening the bed of the river in the vicinity. The results obtained will probably be fully shown in the recent survey made by Assistant Engineer Ewens under the direction of the Commission.

IMPROVING HARBOR AT NEW ORLEANS, LOUISIANA.

(See Plate I.)

The project for this work was approved by the Commission September 18, 1882. The plant necessary for its prosecution having been procured, everything was in readiness and in place for commencing the construction of the mattress 400 feet wide, beginning at the head of the Carrollton bend October 9, 1883. Proposals for furnishing brush were opened after due advertisement September 5, and George W. Davis, being the lowest bidder, was awarded the contract at $1.75 per cord. Requisition was made upon the executive officer of the Commission for the stone for ballast, iron, wire, &c. The first delivery of brush was made October 13, and weaving of mattress commenced October 15. After weaving about 85 feet work was suspended by non-arrival of brush. On November 8 3 barge loads were received, and work recommenced, but after weaving about 190 feet additional, work was suspended again, the supply of brush being exhausted. I have recommended the annulment of the contract and will make other arrangements for procuring brush. On October 9 about 838 yards of stone were received from the executive officer of the Commission. Since then no stone has been received, and I am informed that none can be expected till about the last of this month.

CARROLLTON, LA., *November* 8, 1883.

MAJOR: I have the honor to submit the following report of work done towards improving the harbor of New Orleans since you placed me in charge, which was on the 1st of August, 1883. A steam-tug had been purchased, and the ten barges on which the mattress-ways were to be constructed had been completed in Saint Louis and delivered at Carrollton; and I began at once to get up a plan for joining these barges and for building the mattress-ways on them. I also submitted a plan for building the mattress and estimates of material required. These plans and estimates were approved by you, and the building of the mattress-ways begun on August 21. Owing to the difficulty in getting good carpenters and the slow delivery of material, they were not completed till September 29. The mattress-ways are 28 feet wide and 400 feet long; they are constructed across the ends of ten barges, each of which measure 100 feet by 20 feet. These barges are separated 22½ feet, and are so linked together that high waves cannot injure them or the mattress-ways. In accordance with your order, a storehouse was begun on September 19 and completed on October 4. It is a building 20 feet by 80 feet, and a room 20 feet by 20 feet was partitioned off of one end for an office. All the supplies received for this work and some other property belonging to your department have been placed in this building.

The plant for building mattress was placed in position at the head of Carrollton Bend October 9, and the construction of mattress begun on the 14th. The willow brush is woven on poles, which have iron rods nailed to them. The poles and rods are 25 feet long, and when one set has been woven full of brush another set is linked on. Two No. 8 wires run through and across the mattress every 12 feet of its length, and heavy binding poles are wired across every 25 feet in length. It is proposed to make this a continuous mattress, and to sink it as fast as we weave it. Owing to the failure of the contractor to furnish brush, only about 85 linear feet of mattress have been constructed.

Respectfully submitted.

W. G. PRICE,
Assistant Engineer.

Maj. AMOS STICKNEY,
Corps of Engineers, U. S. A.

In the third-district harbor front, where the annual destruction of the wharves by sliding banks seemed to present a very serious trouble, the experience of the past year has shown a more encouraging condition of affairs. The wharf lessees made a partial experiment of a plan suggested by the Board of Engineers, viz, the scouring out of the high-water deposit under the wharves by turning the propeller of a tug, the tug being made fast in a proper position. The result of this experiment was so satisfactory where the wharves were so constructed as to permit a proper application of the scouring current from the tug wheel that it is hoped a more favorable shape of wharf and thorough application of the tug scouring after each high water will prove an effectual remedy. On July 31, 1883, the following letter was addressed to Mr. Kirk, in charge of the wharves. No reply has been received from him:

UNITED STATES ENGINEER OFFICE,
New Orleans, La., July 31, 1883.

SIR: I desire to call your attention to a method of preventing the caving of bank and consequent destruction of wharves along the river front in third district. The Board of Engineers, of which I was a member, and which assembled in this city in the fall of 1881, recommended in their report (as one of the means that might be tried to prevent this caving) the washing out of the high-water deposit under the wharves by turning the wheel of a tug, so placed as to send a current in the proper way. This, I am informed, was tried to a certain extent last summer with very satisfactory results. As this is a matter of very considerable importance to you in the maintenance of your wharves, I write to ask you to give the plan a more systematic and thorough trial. As the water is now falling, it would be well to commence as soon as possible, before the deposit begins to slide. If this proves to work satisfactorily, all wharves built in future could be so planned as to admit of the proper placing of the tug, and the annual cost of the work would be small. If you conclude to make the trial I would like to have one of my assistants make measurements to note the results, and to give you any assistance that he could with reference to determining the proper points for scouring.

Very respectfully, your obedient servant,

AMOS STICKNEY,
Major of Engineers, U. S. A.

MR. GEORGE H. KIRK,
New Orleans, La.

In my letter of September 16, 1882, to the Commission, submitting project for improvement of New Orleans Harbor, I called attention to the fact that at other parts of the harbor work would probably be necessary, and that the experience gained and results arrived at in Carrollton Bend would be a guide for the extension of the work. During the past summer very extensive caving of the bank has occurred in the Gouldsborough Bend, and above, on the right bank of the river, the extensive wharf and a part of the large depot building of the Texas Pacific Railroad sunk into the river. The commercial importance of this part of the harbor is rapidly increasing, as shown in the accompanying letter of Mr. E. B. Wheelock, president of the New Orleans Pacific Railway Company, and report of Assistant Engineer W. G. Price. To thoroughly protect the right bank will require a great deal of work, which should cover both bends and perhaps the straight reach between, as shown in accompanying sketch.

NEW ORLEANS PACIFIC RAILWAY COMPANY,
PRESIDENT'S OFFICE,
New Orleans, La., November 17, 1883.

DEAR SIR: In connection with your present important labors in the neighborhood of New Orleans, I beg leave to call your attention to the condition of the bend from Westwego to Algiers, opposite the first district of New Orleans. This bend is rapidly becoming one of the most important portions of the harbor of New Orleans. The Morgan Railroad, managed by the Southern Pacific, and the Texas and Pacific Railway, now operating the property and franchises of the New Orleans Pacific, have costly and needful termini at this point, where facilities must exist for handling the commerce of the Southwest and West, including the Pacific slope. Wharves and transfer facilities have already been built at lavish expense, and more are needed. Besides the railways there are such important enterprises begun on the same shore, as the terminal facilities of the barge companies, compresses and warehouses for cotton, grain elevators, cotton-seed mills and storehouses, and wharves for other purposes. At the upper end of the bend opposite Louisiana avenue there is Harvey's Canal, connecting with the network of navigation through the Bayou Barataria. These great and constantly increasing interests of commerce and navigation require immediate protection. It is a case of urgency included beyond doubt in the protection of commerce and navigation by the National Government. If the river be controlled at that point, the depots, tracks, inclines, wharves, compresses, and elevators designed for the trade of half of the continent will be secure and useful. If the river be at this point not controlled the whole machinery of commercial intercourse above detailed is put in constant jeopardy, its development arrested, and its very existence made a matter of doubt. The remedy for this evil does not seem difficult. It cannot be found in private enterprise. It is not within the jurisdiction or duty of any single riparian proprietor. It would seem to be easily found in the scope of the national power as exercised for the improvement of harbors and the protection of commerce. The caving in this bend has already destroyed the depot of the Texas and Pacific Road, and carried away a portion of an incline and wharf. It has compelled the setting back of a costly levee at great expense. It threatens the entire commerce above described and may occur again at any point from Algiers to Westwego. I have thought it not improper to ask your kind attention to this subject, and to bespeak for it your consideration. I may add that on the 2d instant I addressed a statement of the facts to Hon. B. F. Jonas, of the United States Senate, and the communication was concurred in and indorsed by the following gentlemen: Duncan F. Kenner, president Planters, and Crescent Oil Company; A. Schreiber, president New Orleans Warehouse Company; John Phelps, president Cotton Exchange; R. S. Howard, president Chamber of Commerce; W. J. Behan, mayor of New Orleans; Gomila & Co., managers Relief Elevator and Warehouse Company; Morgan's Louisiana and Texas Railroad and Steamship Company, per A. C. Hutchinson, president.

Very respectfully yours,

E. B. WHEELOCK,
President.

Maj. AMOS STICKNEY,
Corps of Engineers, U. S. A.

NEW ORLEANS, LA., *November* 19, 1883.

MAJOR: In accordance with your order, I have obtained the following information in regard to values of property on the river front in Gouldsborough and Gretna, between Harvey's Canal and the upper line of Orleans Parish, as follows:

Texas and Pacific Railroad terminus	$400,000
Gomila & Co., barge interest	50,000
New Orleans Compress and Warehouse Company cannot establish works unless bank is protected	150,000
Richard Street Ferry Company suffer from caving banks. Morgan's Railroad, warehouse and terminus at Gretna	200,000
Jackson Street Ferry Company suffer from caving banks.	
Union Oil Mills	300,000
Crescent City Oil Mills	300,000

Each of the oil mills has large wharves. These values represent the cost of property located there, but they would not begin to cover the value of interests if they were lost. The value of the property above Harvey's Canal and below the upper line of Orleans Parish I have not had time to get. I find from the above that the river front in this bend is being occupied for railroad termini, transfer facilities, warehouses, and similar constructions. These things are all used for purposes of commerce and navigation, and they cannot be safely used unless the bank is protected.

LENGTH OF BANK TO BE PROTECTED.

In accordance with your order, I have divided the river bank which needs improvement into three sections. The first begins 3,100 feet above the Company Canal, and ends 2,800 above Harvey's Canal, and is 20,300 feet long. The second section begins at the end of the first, and ends 3,800 feet below Harvey's Canal, and is 6,540 feet long. The third section begins at the end of the second, and ends at De Armas street, in Algiers, and is 13,600 feet long. Owing to the interests located along the third section, it needs improvement much more than other sections, but the work, to be permanent, must soon be carried around the whole bend. In accordance with your order, two methods of improvement have been worked out and estimates of the cost of each made.

FIRST METHOD.

This is the same that is being put down in Carrollton Bend, and consists of a continuous mattress 350 feet wide, ballasted with rock. Data obtained from the Carrollton Bend work shows that it will cost 4.42 cents per square foot. There are two objections to this method of improvement: First, the difficulty in laying a continuous mattress where there are wharves in constant use; and, second, the probability that the mattress would be wrecked by the sliding down of wharves, under which a bank of silt had collected.

SECOND METHOD.

This consists of a system of dikes built out at right angles to the bank and from 500 to 1,600 feet apart. A mattress 350 feet by 100 feet will first be laid and then a dike 30 feet wide, 20 feet high, and 300 feet long will be laid on the center of the mattress, reaching to within 50 feet of the deep-water end of the mattress. The dike will consist of willow brush and stone. The brush will be woven in thicknesses of 4 or 5 feet and sunk one on another till a thickness of 20 feet is reached. In this bend a dike 20 feet high will carry the bank out horizontally about 60 feet. The current, passing a dike and moving in a line tangent to the curve above, will strike the bank again in about 750 feet, where another dike would have to be constructed. As the bend is somewhat irregular, the dikes would have to be nearer together at some places and farther apart at others.

The mattress under the dike would cost, at 4.42 cents per square foot	$1,547
The dike, at 4.97 cents per cubic foot, would cost	8,946
Making a total cost of mattress and dike	10,493

I have estimated stone to cost $3 per cubic yard, loose measurement, and the dike to contain 5.1 pounds of stone, weighed in water, per cubic foot, over the amount necessary, to overcome the buoyancy of the brush. This weight would be increased by the sand and silt which would collect.

COST OF THE IMPROVEMENT.

FIRST SECTION.

Length of section ... feet	20,300
Cost to protect with mattress	$314,000
Cost to protect with dikes, 750 feet apart	294,000

SECOND SECTION.

Length of section ... feet	6,540
Cost to protect with mattress	$101,000
Cost to protect with dikes, 1,635 feet apart	42,000

THIRD SECTION.

Length of section ... feet	13,600
Cost to protect with mattress	$210,000
Cost to protect with dikes, 750 feet apart	189,000

The entire third section is a caving bank, and if not protected it will in time cut away Algiers, and change the whole front on the opposite side of the river.

Respectfully submitted.

W. G. PRICE,
United States Assistant Engineer.

Maj. AMOS STICKNEY,
Corps of Engineers, U. S. A.

The following is a financial statement of the different works in my charge:

CONSTRUCTION AND REPAIR OF LEVEES, FOURTH DISTRICT.

	Atchafalaya front.	Tensas front.
Allotted	$110,000 00	$426,160 00
Drawn	100,000 00	426,160 00
On hand, Assistant Treasurer, New Orleans, October 31, 1883		174,529 19
Expended to October 31, 1883	102,947 22	251,630 81

Balance, December 1, 1882	$44,966 98
Received since	476,160 00
	521,126 98
Expended to October 31, 1883	349,545 01
Balance on hand, October 31, 1883	171,581.97
Disbursements since December 1, 1882:	
Transportation	1,949 97
Miscellaneous	9,034 59
Inspection of contract work, salaries	$11,720 50
Contract work on levees and protection during high water	326,839 95
Total since December 1, 1882	349,545 01

SURVEY OF UNLEVEED FRONTS, FOURTH DISTRICT.

Allotted	$1,000 00
Drawn or expended	--------

NATCHEZ AND VIDALIA.

Transferred, September 9, 1882	$7,529 09
On hand, Assistant Treasurer, New Orleans, October 31, 1883	5,331 42
Expended since September 9, 1882	2,197 67
Balance December 1, 1882	6,979 01
Expended since	1,647 59
Balance October 31, 1883	5,331 42
Disbursements since December 1, 1882:	
Material	$12 50
Transportation	45 09
Rent of land	50 00
Care of property	1,540 00
Total	1,647 59

First cost of plant at this work is not known. It consists of 4 flatboats, tools, furniture, and implements.

MOUTH OF RED RIVER, LOUISIANA.

In Treasury Department, September 30, 1882	$75,000 00	
Transferred, September 30, 1882	8,153 94	
Drawn	15,000 00	
In hands of assistant engineer	113 02	
Expended since September 30, 1882	37,883 46	
Balance December 1, 1882		
Received since		$15,000 00
Due from appropriation, December 1, 1882	7,123 93	
Expended since December 1, 1882	22,605 59	
Balance due from appropriation, October 31, 1883		14,729 52
Disbursements since December 1, 1882:		
Survey parties, including survey for Plaquemine route	6,238 29	
Miscellaneous	1,878 88	
Dredging operations, including hire of fleet	14,488 42	
		22,605 59
First cost of plant now employed		

SURVEY OF CUBITTS GAP AND VICINITY.

Allotted		$300 00
Drawn	300 00	
Expended to October 31, 1883	137 14	
On hand, assistant treasurer, New Orleans		162 86
Disbursements since December 1, 1882:		
Drayage	$1 00	
Stationery	3 75	
Telegrams	6 70	
Material	8 51	
Provisions	40 10	
Services	77 08	
		137 14

IMPROVING MISSISSIPPI RIVER—OBSERVATIONS AT CARROLLTON, LOUISIANA.

Allotment		$3,000 00
Drawn		3,000 00
Expended		3,000 00
Balance December 1, 1882		3,000 00
Expended to October 31, 1883		3,000 00
Disbursements since December 1, 1882:		
Telegram	$0 72	
Storage	6 00	
Stationery	10 93	
Lumber	12 39	
Coal	134 15	
Material	187 63	
Transportation	220 60	
Hire of launch	300 00	
Services	2,127 58	
		3,000 00

MISSISSIPPI RIVER COMMISSION—OBSERVATIONS AT CARROLLTON, LOUISIANA.

Allotted		$1,500 00
Expended		1,444 61
Balance on hand October 31, 1883		55 39
Disbursements since December 1, 1882:		
Telegrams	$0 75	
Transportation	15 00	
Material	41 98	
Fuel	72 55	
Service	1,314 33	
		1,444 61

CLOSING BONNET CARRÉ CREVASSE.

Allotted	$15,000 00
Drawn	15,000 00
Expended since December 1, 1882, contract work	15,000 00

HARBOR AT NEW ORLEANS, LOUISIANA.

In Treasury Department, Washington, July 1, 1882	$144,525 90	
On hand, Assistant Treasurer, New Orleans, July 1, 1882	3,267 91	
In hands of Assistant Engineer, October 31, 1883	100 00	
		$147,893 81
Expended since July 1, 1882		8,845 01
Balance on hand December 1, 1882	2,055 79	
Expended since	7,632 89	
Balance due from appropriation	5,577 10	
Disbursements since December 1, 1882:		
Miscellaneous	506 97	
Material	453 88	
Surveys	145 14	
Service at the works	1,966 06	
Office expenses, &c	570 93	
Plant	3,989 91	
		7,632 89
First cost of plant now employed		30,610 31

Very respectfully, your obedient servant,

AMOS STICKNEY,
Major of Engineers, U. S. A.

Lieut. Col. C. B. COMSTOCK,
Corps of Engineers, U. S. A.,
President Mississippi River Commission.

APPENDIX N.

REPORT OF PROFESSORS E. W. HILGARD AND F. V. HOPKINS UPON THE EXAMINATION OF SPECIMENS FROM BORINGS ON THE MISSISSIPPI RIVER BETWEEN MEMPHIS AND VICKSBURG.

BERKELEY, CAL., *May* 4, 1883.

DEAR SIR: I transmit herewith a detailed report and discussion of the examination made by Dr. F. V. Hopkins and myself of the specimens from borings made in 1879 by Assistant Engineer E. H. Wilson, under the auspices of the Commission, at Memphis, Helena, the neighborhood of Choctaw Bar, Greenville, Miss., and in the reaches near Lake Providence, Louisiana. These specimens were received here in June, 1882; but their somewhat laborious microscopic examination was not completed by Dr. Hopkins until January, 1883, when I found it necessary to request the transmission of two other sets supplemental to the five originally selected as representative ones, for the settlement of some doubtful points. The examination of these suggested the need of still further extension of scope, which was accordingly made. The research has now reached a point where its further prosecution would require material not now in the possession of the Commission, and the results elicited are sufficiently definite for the objects had in view, as expressed in your communication to me of December 20, 1881. The age and mutual relations of the formations penetrated have been determined with all attainable certainty; and while in part unlooked for, the results agree perfectly with our investigations heretofore made, and complement them in many important particulars.

While regretting that the views of the Commission do not permit of the engraving and publication of the new forms found and drawn by my colaborer, Dr. Hopkins, I trust that the facts here presented may lead in the future to a more thorough and exhaustive investigation of this interesting subject.

Very respectfully, your obedient servant,

E. W. HILGARD.

First Lieut. SMITH S. LEACH,
Secretary Mississippi River Commission.

REPORT.

UPLAND BORINGS.

In the borings made in the uplands, viz, at Memphis (No. 2) and Helena (No. 2), while the results have corresponded to the expectation based upon the researches of Owen, Safford, and myself, respectively, in the States of Arkansas, Tennessee, and Mississippi, there has been added important confirmation of the inferred position and succession of strata. The remark of Mr. Wilson (p. 144 of the report of the Commission for 1881) that my "study of the northern lignitic formation in Mississippi had not disclosed any westerly dip" is correct so far as my report of 1860 is concerned, but subsequent observations showed me the regular disappearance below water-level of the northern lignitic strata in following the westward course of the Tallahatchee and Yockeney Patafa, implying a westerly dip of at least 5 feet per mile in that latitude. Very nearly in accordance with this estimate, the characteristic "Flatwoods Clays," which disappear under the sandy strata of the "Lagrange Group" of Safford at a point 75 miles east of Memphis, are struck at Memphis at the depth of 168.5 feet, and are here over 100 feet in thickness. The clay is overlaid by the equally well characterized materials of the Lagrange Group, on which rests a thick deposit of "orange sand" in its most characteristic features; that is in its turn capped by the loess or bluff materials, which here, however, have the somewhat abnormal composition which I have designated as "marginal loess." All of these data are in entire accord with what has been observed inland.

At the Helena Bluff boring we have the highly characteristic loess material of great thickness, underlaid by only a thin band of orange sand, whose variation in thickness, here as elsewhere, is one of its prominent features, it having been instrumental in the excavation of channels and erosion of the surfaces upon which it has been deposited. Beneath it, and but a few feet below high-water level, appears the tertiary marl, with the same type of fossils as that found by Owen inland from Helena, cropping out in the bluffs of the streams.

It may be necessary here to express my dissent from the conclusions of Mr. Wilson in regard to the causes of the smallness of the fossils brought up by the auger in his borings, which he inclines to consider as the result of imperfect development in consequence of the influx of fresh water. At the early time at which these, the equivalents of the Claiborne beds of Alabama, were formed, the continental drainage had its mouth above Cairo, and the Mississippi of to-day had not yet become the one great outlet, the Missouri having no existenec. A gradual upheaval, prevalently from the eastward, was shallowing a part of the great Mississippi embayment, so as to convert its margin into swamps, intersected by occasional estuaries. Such continued to be the state of things to middle tertiary times over much of the States of Mississippi and Louisiana. Yet we find in the intercalated marl the largest and finest fossils; moreover, as a matter of fact, there *are* fragments of large fossils in several instances—*e. g.*, *Venericardia planicosta*, *Atletha Tuomeyi*, *Monoceros vetustus*, and others. As a rule such large fossils would be driven out of the way by the pipe in its descent, or ground to fragments. The smaller, and especially those combining hardness with smallness, would be the ones that the auger would leave comparatively uninjured, such as *pleurotomas*, *naticas*, *&c.*

Such as they are, however, these fossils overwhelmingly demonstrate the close correspondence of the beds penetrated at Helena and Choctaw Bar (whose *facies* is altogether identical) with the lower portion of the Claiborne beds of Alabama; perhaps most nearly with those older ones, which Dr. Eugene A. Smith, State geologist of Alabama, has lately examined at and near Wood's Bluff, Alabama, and which rest directly upon the oldest lignitic and flatwoods clays. This is obviously the position of the Helena marl bed, since he clays found in the bottom boring, No. 1, at 162.3 feet and lower, are absolutely indistinguishable from those of the Memphis boring. These facts agree again with the fact that, since the strike of the Claiborne strata observed in Mississippi is about west-northwest (not due west, as inferred by Mr. Wilson from the older geological map of Mississippi), their dip must be correspondingly a south-southwesterly one, from Memphis toward Helena.

The difference of nearly 150 feet between the levels at which the tertiary strata have been reached in the bluff and in the bottom boring at Helena, not quite two miles apart, affords a measure of the energy of the erosion effected by the gravel-charged floods of the quaternary epoch.

BOTTOM BORINGS.

In all the deeper bottom borings, save one (viz: No. 2, Lake Providence), three distinct formations have been penetrated, viz, the river alluvium or its equivalents in time, the equivalents of the Port Hudson beds, and the eocene tertiary strata.

Much speculation has been indulged in heretofore as to the average depth of the alluvial deposits of the Mississippi, and the results of my observations in the Delta, which seemed to indicate that the deposits of the modern river are comparatively shallow even there, have been repeatedly called in question. The present investigation throws much light on this subject, and likewise rectifies the interpretation of the age of the "bottom gravel," which has long been known to underlie the great bottom, but was by myself conjectured to be, in the main, the representative of the "orange sand" of the uplands. Mr. Wilson correctly concludes, from the constant occurrence through these gravels of lignite grains or "wash," that they are not an equivalent of the orange sand, which is always singularly free from any oxidizable matter. The microscopic examination corroborates the importance of the lignite grains, and associates them with grains of carnelian, and clear quartz spotted with carnelian as characteristics of the Port Hudson strata, to which group the great beds of gravelly sand with the overlying finer sands are accordingly referred. On the other hand the same examination shows the vegetable remains in the alluvium to be merely macerated, or slightly carbonized, detecting no other fossils at all.

It is not altogether easy to see why this should be so, and why a few remains of rootlets or wood fibers, and rarely even these, should be all that remain of the multitude of objects that the great river has an opportunity of carrying off in its long course, especially at high stages of water. The only reasonable explanation seems to be that the triturating effect of the sharp sand, with the rapid eddying motion of the river, tends to destroy, by mechanical attrition, all but the toughest material and such large fossils as logs. It cannot but be presumed that in the back or slack-water deposits of to-day some of the many organisms of the cypress swamps must be preserved; but no such material has come under our examination. On the whole, a person habitually familiar with the deposits of the river will rarely fail to recognize them. Moreover, they are all, even to the sand-bars, characterized by a very frequent alternation of materials, due to the alternate influx of deposits from different sources at different seasons of the same year, so that a close observer may in many cases identify the materials deposited by floods derived from different rivers, such as the Arkansas on the one hand, and the Red River on the other. On the whole, as great a thicknes as 20, or even 15 feet, of uniform and unquestionably alluvial deposits of to-day will rarely be seen, even 10 feet being unusual, and from a few inches to 2 or 3 feet the most common range.

From this point of view, the great sand bed of boring No. 1, at Helena, as well as those lying beneath the unquestioned alluvium in the Choctaw Bar borings, and in No. 1 of Lake Providence reaches (Mayersville), presented a doubtful point, these sands being remarkably uniform in their nature and appearance, not only at different depths in the same locality, but even on comparison of those from different borings. The fact that in all these cases the massive sand-beds show both the lignite grains and those of quartz spotted with carnelian, which they have in common, not only with each other, but with the typical "buckshot clay" of known Port Hudson age, of which an authentic sample was fortunately in my possession,* is sufficient, in the absence of fossils, to cause them all to be referred to the Port Hudson epoch. It is a curious fact that this buckshot clay, which is so abundant in the back lands of the bottom, happened not to form the surface at any point where borings were made, unless it be at Greenville. Stiff clay soils were in several cases found at the surface, but these were underlaid by the undoubted river alluvium.

The *Greenville* boring is unique, in that it was made at a point in the bottom apparently above high-water mark, and that coincident with this the red and spotted quartz grains with lignite were found in the sand within a few feet of the surface. No microscopic organisms were found in the surface soil, but even that is unlike the river alluvium. In other words, it seems as if at Greenville the older (Port Hudson) materials were, at the surface near the river bank, as some distance back they are on the "buckshot" lands, uncovered by any alluvium. The local elevation of Greenville would be analogous to the "Dogwood Ridge" shown on the map of the Mississippi alluvial region in Humphreys and Abbot's report, as the only land above overflow in the Yazoo bottom.

Finally, the deepest boring of the whole series, No. 2 of Lake Providence, is unique in that, despite of its great depth (248 feet), it has failed to reach the tertiary beds. Mr. Wilson was misled by the close resemblance of the clays at 131.5 feet and below, and also by the overlying lignite, into the belief that the rest of the boring was in tertiary materials, which conclusion was made more plausible by the occurrence of calcareous nodules and materials resembling greatly the tertiary marls. The microscopic examination, however, leaves no doubt of the fresh water and "Port Hudson" character of the entire boring from at most 42.9 feet down. In this latitude, moreover, the outcrops of similar materials in the Yazoo bottom render the identification, even to the naked eye, altogether complete. How much deeper the trough was excavated into the tertiary at this point is open to conjecture; but the occurrence of the tertiary marl at 110 feet in boring No. 3 (at Hay's Landing), 6 miles southeast from Lake Providence, shows that the deep trough was not continued in that direction, but more probably in a southwesterly course. In this connection it should not be forgotten that, as I have shown,* the great drift current bore, not in the direction of the present mouths of the Mississippi, but toward Vermilion Bay. This, therefore, is the direction in which we would expect to find the deepest excavations in the tertiary materials.

As regards the comparative age of the marine tertiary beds at Lake Providence (or rather Hays' Landing) and Choctaw Bar or Helena, the larger as well as the microscopic fossils tend to show that while the beds reached at the first-named locality have a somewhat different *facies* from those above, yet the horizon of the next higher group, the "Jackson," had not been reached. Now it is known that southeast of Hays' Landing on the Yazoo River, near Haines's Bluff, the Jackson strata begin to disappear beneath the water level, being there overlaid by a lignitic bed of variable thickness, which in its turn, at the Vicksburg bluff, is capped by the "Vicksburg" series. The dip of the tertiary being here very little west of south, it follows that at Hays's Landing the strata struck at 110.7 feet must belong to a group considerably below the Jackson beds; which is in effect what the fossils found also indicate. In other words, the bed belongs to the higher portion of the Claiborne group, and, according to the rate of dip observed at Vicksburg, the Jackson beds would not be reached in a boring of that depth until about the latitude of Warrenton, south of Vicksburg.

The general conclusions reached as regards the geological history and structure of the great bottom within the limits of the borings in question are therefore these: A trough whose depth exceeds at one point 248 feet below high-water mark has been excavated into the tertiary beds originally filling it probably to a height considerably above that mark.† This trough has subsequently been filled up to above present high-water mark with deposits dating, in their present position, from the period of gradual depression following the deposition of the orange sand, and during which the orange-sand materials were eroded and redeposited in the trough, or similar materials were brought *de novo* from northern regions. The gravel and coarser sand were of course left in the more northerly portion of the trough, while in the southerly one the comparatively slack water produced deposits of sandy loams, fine silt, and "buckshot" clay. As the depression increased and the slack-water advanced up the valley, finer materials, like the sands overlying the gravels, were deposited, and finally the loess and yellow loam now covering the uplands. Upon re-elevation the loam and loess in the middle portion of the trough were washed away; but when the resistent buckshot clays were reached erosion concentrated upon the lines of least resistance, and the river of to-day was formed. The great alluvial ridge in the axis of the valley shows that while the river has shifted its channel by the formation and cutting off of bends, its general location has roughly remained the same. Where the river has washed away the ancient deposits it has left its alluvium overlying such as remained; but while at many points the alluvium *filling old river-beds* must, of course, be of corresponding thickness, viz, from 70 to 100 feet, or perhaps more, alluvium of such thickness has been struck only in boring No. 5, Choctaw Bar, viz, 68.2 feet; the maximum thickness found elsewhere being (in the case of the Hays' Landing or Lake Providence No. 3 boring) 56.8 feet, and mostly between 25 and 40 feet. This is in accord with the similarly shallow depths at which the alluvium was found to terminate in the lower delta.

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* For geological details regarding this clay, refer to Dr. E. A. Smith's paper on the Geology of the Mississippi Bottom, Proceedings A. A. A. S., 1871, p. 252.

It would be extremely desirable to verify these conclusions by the comparative examination of samples carefully taken, both of various kinds of modern alluvium, and of various materials of the noted out-crops of the Port Hudson group. This would be especially interesting in connection with borings made at points further south in the great valley itself.

PREFATORY LETTER BY DR. F. V. HOPKINS.

SAN FRANCISCO, CAL., *May* 1, 1883.

PROF. E. W. HILGARD, *Ph. D.*:

DEAR SIR: The microscopic examination of the specimens submitted to me by you has now been carried as far as the objects had in view by the Mississippi River Commission will warrant. In fact, it has been carried much farther, for under the impression that what was desired was a full account of their fossil contents, such as I had the pleasure of preparing for you in the case of the Lake Borgne borings in 1874, I figured carefully every organism observed. The tertiary marls proved to be very rich in foraminifera, almost all of undescribed species, and one or two new genera may have to be created in order to describe them fully. This work, after having occupied my time for months, unfortunately proves to be of little avail, the Commission having decided at their meeting in January last to publish no plates with this report.

Under these circumstances I have done what I could to compare my specimens with those already described, and have prepared lists of names, indicating the figures in the works of others that most strongly resemble the fossils observed. These names appear in the following tables, and will no doubt aid in the determination of the geological position of the strata through which the borings have passed. It is to be hoped that they may attract the attention of naturalists to a rich and as yet unworked field for scientific research.

The specimens were prepared for examination by shaking, or in the case of clays by boiling, with about 4 inches of water in a 6-inch test-tube until the grains were well separated. After settling, first for 25 seconds, the water containing the finer portion was decanted into another tube, and a fresh supply poured in. This process was repeated four times, the settling being 5 seconds shorter each time. The remaining portion and the separate deposits in the tubes were then examined carefully under a microscope, with powers varying from 70 to 1,400 diameters. The results are set forth in the following tables.

Yours, very truly,

F. V. HOPKINS.

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* Smithsonian Contributions to Science, No. 248; also, Proceedings A. A. A. S., 1871, p. 230, ff.

† The height at which we find the tertiary beds at this time on the bordering bluffs is probably not a fair measure of the amount of erosion, since the axis of the Mississippi embayment was undoubtedly a trough lower than its border.

Record of examination of specimens of borings.

[Microscopic character by Dr. F. V. Hopkins; larger organisms and final determination of the strata by Prof. E. W. Hilgard.]

BORING NO. 2, MEMPHIS, TENN. (ON BLUFF).

Description of specimens.	Depth.	Quartz.	Tourmaline	Vegetable matter.	Mica.	Large fossils.	Small fossils.
LOESS.	*Feet.*						
Yellow silt, non-calcareous.	1 to 47	Small rounded and clear.	None..	A little.	None..	None..	None.
ORANGE SAND.							
Orange yellow, coarse sand.	47 to 55.9	Variegated with pebbles.	None..	None..	None..	(*)	None.
Blue clay, with yellow streaks.	55.9 to 60.6	Small, clear, and rounded.	....do....	....do....	....do....	None..	Do.
Yellowish sand...........	60.6 to 63	Clear, mixed with chert and jasper.	....do....	....do....	....do....	....do....	Do.
Coarse sand with gravel.	63 to 93.9	Sharp and rounded, clear, white, yellow, red, and black.	....do....	....do....	A little.	(†)	Do.
Orange-colored sand...	93.9 to 99.8	Variegated...........	....do....	....do....	....do....	None..	Do.
Orange-colored sand, gravelly.	99.8 to 117	......do....................	....do....	....do....	....do....	(†)	Do.
Orange-colored sand, lower part cemented by iron into a conglomerate.	117.5 to 132.2	......do....................	....do....	....do....	....do....	(†)	Do.
Whitish clay...............	132.2 to 132.5	Fine and clear.	....do....	....do....	....do....	None..	Do.
Coarse yellowish sand.	132.5 to 133.4	Variegated............	....do....	....do....	....do....	....do....	Do.
Whitish clay...............	133.4 to 134.1	Fine and clear........	....do....	....do....	....do....	....do....	Do.
Coarse yellowish sand.	134.1 to 139.3	Variegated............	....do....	....do....	(‡)	....do....	Do.
NORTHERN LIGNITIC TERTIARY.							
Lagrange Group.							
Gritty clay, yellowish, passing into bluish gray.	139.3 to 150	Clear, small, and rounded.	None..	(§)	None..	None..	None.
Gray sand..................	150 to 154.5	Rounded and sharp, clear, some white and yellow.	....do....	....do....	....do....	....do....	Do.
Flatwoods Group.							
Stiff blue clay..............	154 to 167	Very small, clear, and round.	None..	None..	None..	None..	None.
Grayish sand..............	167 to 168.5	Clear and round.....	....do....	....do....	....do....	....do....	Do.
Stiff blue clay..............	168.5 to 275.1	Fine and clear........	....do....	(‖)	....do....	....do....	Do.

* Casts of palæozoic in pebbles. † Casts in pebbles. ‡ A good deal. § Lignite grains and larger pieces ‖ Lignite grains.

NOTES ON MEMPHIS SECTION, BORINGS NOS. 1 AND 2.

(E. W. HILGARD.)

The loess specimens within the first 47.2 feet agree entirely with the usual character of this deposit in the northerly region. It is much less calcareous than farther south, and snails, as well as concretions of calcic carbonate, occur only in streaks, sporadically. The upper 10 feet are properly a subsoil layer belonging to the "yellow-loam" division, which in the interior is directly superimposed upon the orange sand or stratified drift.

The latter presents here a most characteristic section, embracing a series of all its characteristic materials, even to the ferruginous conglomerate of coarse sandstone, which here, as elsewhere, marks the approach to an impervious or clayey layer. The lowest portion of the loess also shows for a few feet a change toward a sandy hardpan, which usually forms a transition to the orange sand proper; and at the base of the latter the increase of sharp sand-grains, as against the rounded and rust-incrusted ones, heralds the approach of the tertiary sands that commonly form the upper portion of the "Lagrange groupe" in Tennessee. The great clay bed with occasional streaks of gray sand is the exact counterpart of sections obtained in bored wells in the "Flatwood belt" in Mississippi, including the variation in sandiness that is so apparent between 230 and 245 feet of the section. As these clays immediately overlie the highest cretaceous of the southwestern States, it is probable that between 100 and 200 feet lower down the cretaceous limestone would have been reached after passing through a zone of estuarian deposits with silicified marine fossils. The dark-colored concceretions found at 184.7 and 204 feet are mostly of bird-shot size, and consist of sand-grains cemented by brown iron ore, evidently a pseudomorph after iron pyrites. They are therefore not calcareous, as stated in the record of borings; nor does the material inclosing them show any signs of effervescence. Had it been otherwise, the fact would have been of especial interest, as indicating the approach of oldest marine tertiary strata found at some points in Mississippi and Alabama.

Boring No. 3 manifestly agrees in all prominent points with the sections obtained in the bottom borings at Helena, Choctaw Bar, and Lake Providence; viz: the tertiary strata are overlaid first by a heavy deposit of gravel and gravelly sand, this by finer sand, and this finally by the obviously alluvial layers.

BORING No. 1, IN BOTTOM LAND, HELENA, ARKANSAS.

[Specimens from below the depth of 81 feet. No microscopic organisms detected.]

Description of specimens.	Depth.	Quartz.	Mica.	Lignite.
Port Hudson.	*Feet.*			
Fine sand	81 to 45.0	Grains clear, rounded, and sharp, some red; largest .085 inch in diameter.	But little; some red and green, mostly colorless; no tourmaline.	None.
Fine sand	45 to 87.4	As above, from .017 inches down.	Plentiful in broad plates	Abundant. Too ripe for an alluvial deposit.
Coarser sand with gravel	87.4 to 116.4	Rounded, mostly colorless, but varied with milky quartz, carnelian, yellowish chert, &c.	None	Do.
Clean sand with gravel	116.4 to 142.7	Perfectly rounded, mostly clear; some spotted with carnelian, chert, jasper, quartz, &c., and fragments of composite rocks, gray and brown.	do	Not very abundant.
Coarse sand	142.7 to 156.8	do	do	Do.
Finer sand	156.8 to 161.5	do	do	Do.
Coarse sand	161.5 to 162.8	do	do	Do.
Northern lignite (tertiary):				
Smooth blue clay	162.3 to 189.5	Very fine, clear, and rounded	do	Abundant and ripe.
Lignite in mass	189.5 to 189.7	None	do	Well ripened.
Smooth blue clay	189.7 to 206.4	Very fine, clear, and round	do	In grains, ripe as last.

BORING No. 2, HELENA, ARK.

Description of specimens.	Depth.	Quartz.	Tourmaline.	Large fossils.	Small fossils.
	Feet.				
Loess:					
Brownish-yellow loam, non-calcareous.	0 to 0.5	Brown yellow and clear; grains from .03 of an inch down, smaller, grains sharp, larger rounded.	None	None	None.
Yellow silt, calcareous, and full of snail shells and concretions of lime called "loess puppets."	0.5 to 139.7	Clear rounded and sharp, from .002 of an inch down.	Green crystals of tourmaline.	*Helix albolabris* (Say)	Do.
Transition stratum:					
Yellowish clay	139.7 to 167.8	Clear rounded .002 of an inch and less in diameter.	None	None	Do.
Orange sand (drift):					
Chert pebbles	167.8 to 171.8	Yellowish chert, well rounded, often several inches in diameter; full of casts.	do	Casts of palæozoic fossils	Do.
Claiborne group of Tertiary strata (Marine):					
Stiff blue clay, with green sand and lignitized sea-weed.	171.8 to 199	Clear and round; some carnelian.	A little crystallized	*Corbula*, *Turbinolia*, *Natica magno-umbilicata*, *Voluta petrosa*.	Do.
Stiff blue clay, calcareous; a clayey green-sand marl.	199 to 211.2	do	do	*Corbula*, *Turbinolia*, *Natica magno-umbilicata*, *Voluta petrosa*, fragments.	Do.
Ferruginous concretion of stony hardness.	211.2 to 211.4	do	None	Fragments	Do.
Clayey green-sand marl	211.4 to 212.8	Clear and round, $\frac{1}{100}$ of an inch in diameter, and less.	A little in crystals	Same species as at 171.8	Do.
Do.	212.8 to 222	do	do	do	Spot of *Dentalium*.
Do.	222 to 229.5	do	do	do	Spot of *Dentalium*, with spot of *Ostrea*.
Do.	229.5 to 231.8	do	do	do	Abounding in foraminifera, viz: *Planulina*, sp.; *Planulina*, near *P. leptostigma* Ehr.

Description of specimens.	Depth.	Quartz.	Tourmaline.	Large fossils.	Fossils, microscopic.
Claiborne group of tertiary strata:	*Feet.*				
Clayey green sand marl.....	229.5 to 231.3	Clear and round; $\frac{1}{100}$ of an inch in diameter and less.	A little in crystals.	Same species as at 171 3.	*Planulina* n. *ampla* Ehr. two species. Do. n. *octenaria* Ehr. Do. n. *cornu* Ehr. *Cristellaria*, sp. undet. 2. Do. n. *arcuata* Williamson. *Lenticulina*, n. discus, Ehr. *Discorbina*, ten species undet. *Rotalia*, two species undet. *Rotalina*, n. Ehrenbergii Bailey. *Globigerina*, sp. undet. Do. n. *helicina*, Carp. *Sphaeroidina*, sp. *Polystomella* n. *craticulata*, Carp. *Glandulina* n. *laevigata*, D. orb. *Strophoconus*, sp. undet. *Polymorphina*, sp. undet. No. 1. *Vaginulina* n. *tenuis*, Ehr. *Textilaria*, 3 species undet.
Do..................................	231 to 231.3	.........do...	Crystals..............	......do...................	*Rhizopoda*, *Plagiophrys*, sp. undet. *Haliomma*, n. *ovatum*, Ehr. *Foraminifera*, as follows: *Miliola*, n. *ovum*, Ehr. *Gromia*, sp. undet. *Lagena* (*entosolenia*), n. *globosa*, W. Do. n. *squamosa*, W. Do. n. *marginata*, W. *Rotalina*, n. Ehrenbergii Bailey. *Cristellaria*, n. *arcuata*, W. sp. 2. Do. sp. No. 3, undet. Do. sp. No. 4, undet. *Globigerina*, sp. No. 3, undet. *Discorbina*, sp. No. 11, undet. *Bulimina*, sp. undet.
Clay-colored calcareous rock.	231.3	.........do...	None..................	Fragments..........	None.
Dark sandy clay, with pebbles.	234 to 236.8	.........do...	......do..................	None..................	None.
Clay-colored sand*.............	236.8	Clear, sharp, and rounded, some grains spotted with carnelian.	Rare.....................	Fragments very abundant.	*Lagena* (*entosolenia*), n. *marginata*, W. sp. No. 2. *Cornuspira*, sp. undet. *Trochammina gordialis*, Carp. *Spiroloculina*, sp. undet.

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*By some mistake Mr. Wilson reports the last specimen as "limestone."

NOTES ON THE HELENA SECTION.

(E. W. HILGARD.)

BORING NO. 2 (ON BLUFF).

The first 139.7 feet of this section is highly typical loess, with land snails (*Helix albolabris*) and loess puppets or calcareous concretions of the silty mass. It differs quite obviously from the yellowish and much more clayey material of the Memphis bluff and the marginal region of the loess in Tennessee and north Mississippi generally, which may properly be distinguished as "marginal loess."

The materials found from 139.7 to 158 feet, though non-effervescent, seem most closely related to the loess, and, with the underlying siliceous clays, seem to correspond to the transition strata between the loess and orange sand observed at Vicksburg and Grand Gulf, Miss.

The pebble bed at 167.8 to 171.3 doubtless represents the orange sand pebble bed, which has been found of such very variable thickness by Mr. Wilson in this very locality, and shows the same variability almost everywhere else.

The fossiliferous clay and marl bed, 171.3 to 231.3, with its intercalated layer of bluish impure limestone, is very distinctly characterized as tertiary, of the (marine) Claiborne Group by the well-preserved specimens of the following shells: *Monoceros vetustas* Lea, *Actæon lineatus* Lea, *Nucala magna* Lea, *Dentalium turritum* Lea, or *microstriatum* Heiler, *Natica minima* Lea, *N. magno-umbilicata* Lea, *Pleurotoma Lonsdalii* Lea; there is besides an undescribed *Pleurotoma*, *Flabellum*, and *Retepora*. The abundance of microscopic organisms shown by Dr. Hopkins's record is very remarkable.

BORING NO. 1 (IN BOTTOM).

This boring begins at a level about 138 feet lower than No. 2, and reaches to a depth greater by 116 feet. After penetrating 27 feet of unquestionable alluvium, it penetrates first 56.4 feet of very fine and uniform sand, which then becomes coarser and slightly gravelly through the succeeding 29 feet, making 85.4 feet of sand. The materials then become gravelly and pebbly, and so continue with variations to 162.3 feet, making in all 131.3 feet of sandy and gravelly materials, the physical composition of which shows them to belong to one and the same epoch. Then follow strata of solid clays, void of marine fossils, but agreeing in every character with the "northern lignitic" clays penetrated in the Memphis boring at the lower depths. Helena boring No. 1 has therefore passed beyond the limits of the marine Claiborne strata found in boring No. 2, reaching the oldest underlying tertiary at the lowest level at which it has been found in the borings under consideration, viz, 162.3 feet below the high-water reference level. The ready disintegration of the calcareous marls has allowed the ancient floods, charged with gravel, to wear them away down to their tough floor clays; the latter, contrary to the statement of the boring record, show no signs of calcareous matter.

CHOCTAW BAR, BORING NO. 11.

Descriptions of specimens.	Depth.	Quartz.	Mica.	Tourmaline.	Microscopic fossils.
	Feet.				
Alluvium:					
Light brown clay with macerated vegetable matter.	0 to 1.2	Mostly clear, some chert and jasper rounded.	A little	None	None.
Fine clayey sand	1.2 to 23.6	do	do	do	Do.
Stiff clay, brown and sandy	23.5 to 50.5	do	do	do	Do.
Port Hudson:					
Fine gray sand with lignite grains.	50.5 to 87.4	Mostly clear, some spotted with carnelian.	None	None	Do.
Very smooth blue clay with lignite grains.	87.4 to 88.4	Small, clear, both rounded and sharp.	do	do	Do.
Grayish sand	88.4 to 89.5	Clear and well rounded	do	do	Do.
Coarse sand with gravel and lignite grains.	89.5 to 104.7	Clear and spotted with carnelian, some green.	do	do	Do.
Brownish gray sand	104.7 to 118.1	do	do	do	Do.
Very coarse sand	118.1 to 121.8	Clear, mixed with chert, jasper, milky quartz, and carnelian.	do	do	Do.
Claiborne tertiary:					
Bluish clay with crystals of pyrites and fragments of shells.	151.0 to 165.5	Clear, round, and sharp	None	A little in clear crystals.	Do.
Clayey marl with green sand	165.5 to 166.5	Peculiarly even, clear, and small, some green.	do	None	*Spiroloculina*, n. *elongata*, Ehrenberg. *Triloculina*, sp. undet. *Porospira*, n. *princeps*, Ehr. *Textilaria*, sp. undet. Nos. 4 and 5. *Rotalina*, n. *Ehrenbergii*, sp. No. 2. *Discorbina*, sp. undet. No. 12. *Cristellaria*, sp. undet. No. 5.
Stiff blue clay	166.5 to 178.0	Very small and clear, with some carnelian.	do	do	None.
Light bluish clay with green sand and shell fragments.	176.8 to 185.1	do	do	do	*Gallionella* n. *distans* Ehr. *Gallionella*, sp. undet. No. 2. *Lithostylidium*, n. *polyedrum*, Ehr. *Lithostylidium*, sp. undet. *Coniostylis* n. *prismaticum*, Ehr. *Dictyopyxis*, n. *cruciata*, Ehr. *Euglypha*, n. *alveolata*, Day. *Bradyina*, n. *rotula*, Eichwald. *Rotalina*, n. *Ehrenbergii*, Bailey, 2 sp. *Lagena* (*entosolenia*), n. *squamosa*, Williamson. *Strophoconus*, n. *ovum*, Ehr. *Polymorphina*, sp. undet. No. 2. *Uvigerina*, sp. undet. *Textillaria*. sps. undet. Nos. 6, 7, and 8.
Limestone, apparently a concretion	185.1 to 185.2	None	do	do	None.

NOTES ON CHOCTAW BAR BORINGS.

(E. W. HILGARD.)

In the profile of No. 2 we have down to 50.5 feet materials such as are currently deposited by the river at the present time; a clayey soil above, such as is formed in slack water; from 1.2 to 23.6 feet, the river silt, not easily mistaken; thence to 50.3 feet an originally bluish, now brownish loam, such as the river forms when silting up old bends, and which can be observed where such deposits are again cut away; all without fossils.

Then comes first a bed of fine sand, 37 feet in thickness, then a thin sheet of blue clay and beneath it coarser sands and gravel, continuing down to 121.3 feet. The considerable thickness and uniformity of the materials of this bed seem to point to the action in its formation of a mightier body of water than the present river. The frequent occurrence of carnelian and reddish quartz grains also seems to distinguish these older sands from the deposits of the present period, in which, on the other hand, mica is usually abundant. Of course these differences cannot be absolute, but only of degree, since the older materials are constantly being used in the formation of modern deposits. On the other hand, the almost constant presence of lignite grains serves to distinguish the gravel deposits of the bottom from the orange sand of the uplands, which is peculiarly destitute of any organic or oxidizable materials.

No doubt is left about the indentity of the marine Claiborne beds by the fossils, of which boring No. 2 has been more prolific than any other of the set. Apart from the abundant microscopic fauna shown in Dr. Hopkins's record, the following larger fossils were identified:

Otolites, abundant; *Venericardia planicosta V. rotunda* Lea; *V. transversa* Lea; *Corbula Murchisona* Lea, *C. gibboso* Lea, *C. compressa* Lea, *Lucina papyracea* Lea? fragment of a *Tellina*, and several of a triangularly ribbed *Cardium; Dentalium turrtum*, Con., or D. *microstriatum* Heilpr, *Natica minimo* Lea, *N. magno-umbilicata* Lea, all abundant. *Orbis rotella* Lea, *Pleurotoma Lonsdalii*, *Pl. Childreni*, *Pl. Beauemontii*, all of Lea, and two other species. *Fusus pagoda* Heilpr., *F. magnocostatus* Heilpr., and two other species. Two species of *Pyruola*, represented only by the spire; *Turritella plebeia* Say, *T. Mortoni* Con., a prettily sculptured *Piccinum*, *Actaeon lineatus*, Lea; *Atletha Tuomeyi* Con; a *Cancellaria* not described by Lea; fragments of a *Mitra*, *Oliva Gracilis* Lea; a badly worn spire of *Monoceros vetustus* Lea.

The other borings from the neighborhood of Choctaw Bar correspond closely to No. 2, except in that the thickness of the alluvial layer, as well as that of the underlying sand, varies from place to place. In No. 5 the alluvium is thickest, being 67 feet. The surface of the tertiary seems to show a trough excavated to 40 feet below its highest point, cutting squarely across the two bends (from No. 3 to No. 2), as though indicating for a distance of 5 miles the direction of the ancient eroding current.

BORING AT GREENVILLE, MISSISSIPPI.

Description of specimens.	Depth.	Quartz.	Mica.	Tourmaline.	Microscopic fossils.
Port Hudson:	*Feet.*				
Yellowish non-calcareous silt	0.0 to 2.4	Mostly clear, some yellow and red; well rounded.	A little	A little, in black crystals.	None.
Light yellow sand or silt	2.4 to 10.0	Mostly clear, some yellow and red; well rounded grains from $\frac{1}{100}$ of an inch down.	do	do	Do.
Coarse sand mixed with silt and grains of lignite	10.0 to 21.5	Larger grains, clear and rounded, some spotted with carnelian, averaging $\frac{1}{10}$ of an inch in diameter; smaller grains like the last, the transition sudden.	do	None	Do.
Bluish clayey silt with lignite grains.	21.5 to 22.8	Clear and rounded	do	A little	Do.
Coarse white sand	22.8 to 26.9	Well rounded; mostly clear; also milky red and yellow chert and carnelian.	None	In crystals both green and clear.	Do.
A sandy brownish blue clay with lignite grains.	26.9 to 28.0	Clear, sharp, and averaging but $\frac{1}{1000}$ of an inch in diameter	In plates, but little	In clear crystals	Do.
Coarse white sand like that at 22.8 with grains of lignite and gravel.	28.0 to 50.2	Rounded from $\frac{1}{10}$ of an inch down; clear, many spotted with carnelian.	In plates but little; some clear, and some a fine red.	None	Do.
Sandy bluish clay as at 26.9	50.2 to 53.5	Clear, sharp, and very small	A little	do	Do.
Coarse gravelly sand as at 28	53.5 to 64.0	Clear, and variegated, well rolled	None	do	Do.
Coarse gravelly sand like the last.	64.0 to 90.0	do	do	do	None noted.
Claiborne tertiary:					
Green sand marl	90.0 to 96.0	Clear and rounded	do	do	*Discorbina*, sps. undet. Nos. 13 and 14. *Cristellaria*, sps. undet. Nos. 6 and 7. *Polymorphina*, sp. undct. No. 8. *Textilaria*. sp. undet. No. 9. *Textilaria*, n. *variabilis*; variety, *difformis*, W. *Textilaria*, n. *variabilis*, var. *laevigata*, Williamson. *Textilaria*, n. *variabilis*, var. *spathulata*, W. *Textilaria*, n. *variabilis*, W. *Planulina*, n. *annulosa*, Ehr. *Cribrostomum*, near *gracile*, Moeller. *Rotalia*, sp. undet. No. 8. *Planulina*, n. *ampleata*, Ehr. *Bradyina*, n. *rotula*, Eichw. *Miliola*, n. *elongata*, Ehr. *Endothyra*, n, *Ponderi*, Moll. *Endothyra*, n. *parva*, Moll. *Contosmylis*, n. *prismatica*, Ehr. *Guttulina*, n. *turrita*, Reots. Echinoid spines.

NOTES ON GREENVILLE SECTION.

(E. W. HILGARD.)

The Greenville section is somewhat unique both in its collocation and in the materials penetrated. The spot chosen lies above high-water mark; and although the material, penetrated down to the depth of 22.8 feet, might from its appearance be taken to be alluvium; yet the fact that above 10 feet the silts resemble in color the transition beds between the loess and Port Hudson strata, while below that level lignite grains and carnelian-spotted quartz grains are abundant, seems to justify the conclusion that no alluvium at all has been penetrated here, and that older material lies at or near the surface.

This is the more credible as the tertiary strata are also here found at an unusually shallow depth, the least at which they have been struck in any of the borings, viz, 90 feet. There seems, therefore, to exist here a ridge analogous to the "Dogwood Ridge" which forms the continuation of Crowley's Ridge, and runs from opposite Helena to the head of Honey Island, diagonally across the Yazoo bottom.

No larger fossils have been brought up by the augur from the Greenville boring, but the marl struck at 90 feet is identical in appearance with that from the Choctaw Bar borings, and the microscopic organisms, while somewhat different from those of the preceding borings, nevertheless bear the same general character. From the known general southward dip of the tertiary, it must be presumed that higher strata are met with at the same depths as we advance southward, beneath the bottom as well as on the bluffs alongside.

LAKE PROVIDENCE (LOUISIANA) BORING, No. 2.

Description of specimens.	Depth.	Quartz.	Mica.	Tourmaline.	Microscopic fossils.
	Feet.				
Alluvium:					
Yellowish non-calcareous silt, with macerated vegetable matter, varying in the proportions of sand and clay every few feet.	0. to 9.6	Rounded and clear, with some grains of jasper and chert.	A little	None	None.
Blue clay	9.6 to 15.6	Clear, small, and sharp	do	do	Do.
Yellowish sand, slightly coherent.	15.6 to 29	Mostly clear, with some grains of milky quartz and chert.	A good deal	do	Do.
Blackish blue clay	29 to 30	Small, clear, and sharp	None	do	Do.
Grayish yellow sand, slightly coherent.	30 to 42.9	Well rounded, clear, and variegated	A little	do	Do.
Port Hudson:					
Loose sand with grains of lignite	54.8	Clear, rounded, and sharp; some grains spotted with carnelian.	Abundant	A little	None.
Fine brownish silt, darker below, with lignite in grains.	56 to 82	Rounded, clear, and red spotted	A good deal	In brown and green crystals.	Do.
Bluish gray clay	82 to 84	Rounded and sharp, clear and reddish.	do	None	Do.
Clayey silt of a terra-cotta color; abundant lignite grains.	100.5 to 101	do	Abundant	None	Do.
Grayish yellow sand; vegetable matter abundant.	101 to 103.2	Rounded, clear, and reddish	do	A good deal	Do.
Brownish clay	103.2 to 104	Small, clear, and sharp	None	None	Do.
Coarse sand with chert pebbles	109 to 127.6	Variegated, round, and sharp	do	do	Do.
Black lignite	127 to 131.5	None	do	do	Do.
Whitish blue sandy clay	131.5 to 170	Clear and sharp	A good deal	A little	Do.
Fine yellowish clayey sand	170 to 191	Clear and variegated; rounded	None	None	Do.
Gray sand with clayey streaks	191 to 247	Clear and smoky; well rounded	do	do	Do.
Blackish brown clay	247 to 248	Small and sharp, clear and yellow	do	A little	*Navicula*, n. *sigma*, Ehr. *Navicula*, sp. undet.

For comparison with the above, an examination was made of a typical specimen of "buckshot" clay collected in Issaquena County, Mississippi; an undoubted Port Hudson locality.

Description of specimens.	Depth.	Quartz.	Mica.	Tourmaline.	Microscopic fossils.
Stiff blue clay with ferruginous concretions, or "buckshot;" lignite grains abundant.	10 inches from the surface.	Mostly clear; some grains red; from $\frac{1}{75}$ to $\frac{1}{3000}$ of an inch in diameter; the larger grains round, the smaller sharp.	None	None	None.

LAKE PROVIDENCE (LOUISIANA) BORING, No. 2.

Description of specimens.	Depth.	Quartz.	Mica.	Tourmaline.	Microscopic fossils.
	Feet.				
Alluvium:					
Non-calcareous clayey silt with abundant vegetable matter, not lignitized. The color is yellowish above, yellow streaked below, and more reddish at the bottom. The proportion of clay varies also every few feet.	0 to 56	Rounded, clear, averaging .002 inch in size; some red grains.	A little	None	None.
Port Hudson:					
Coarse sand with gravel and grains of lignite. A clay streak occurs at 82.5 to 82.6.	56 to 109	Pebbles chert quartzite, &c.; larger sand grains averaging .05 inch, well rounded; smaller, sharp; clear, green, red, and red-spotted.	Very little	Very little	Do.
Upper Claiborne (tertiary):					
Whitish green sand marl. On washing and settling the green sand falls to the bottom, the red sand occupies the middle, and the calcareous débris lies on top.	127 to 132	Almost all red-spotted, rounded and sharp.	None	None	*Foraminifera* very abundant. *Porospira*, n. *princeps*, Ehr. *Miliolina seminulum*, n. var. *oblonga*, Williamson. *Planulina*, n. *ocellaris*, Ehr. *Miliolina*, n. *seminulum*, W. *Cristellaria*, sp. undet., No. 8. *Guttulina*, n. *turrita* Rects. *Textilaria*, n. *cuneiformis* Dorb. *Textilaria*, n. *variabilis*, W. *Pyrulina*, n. *ovulum*, Ehr. *Rotalina*, n. *Ehrenbergii*, Bailey. *Globigerina*, n. *helicina*, Carp. *Polymorphina*, sp. undet. *Uvigerina*. sp. undet. *Textilaria variabilis*, variety near *spathula*, W. *Discorbina*, sps. undet., Nos. 15, 16, and 17. *Truncatulina*, sps. undet., Nos. 1, 2, and 3. *Truncatulina*, near *lobulata*, Walker. *Tinoporus*, sp. undet. *Miliolina*, sps. undet., Nos. 1 and 2. *Heterostegina*, sp. undet. *Rotalia*, sps. undet., Nos. 4 and 5. *Polystomella*, sp. undet.
Green sand marl like the last, with calcareous concretions containing shell fragments.	132 to 135	Mostly red-spotted as above	do	do	The first ten of the preceding list, besides a *Polycystina*, undet.

Concretions from marl bed, with shell fragments.	145 to 150	None	do	do	None.
Bluish clay with lignite grains	158 to 160	Very small and clear; none red	do	do	Do.
Fine sand of a clay color, with green sand.	166 to 176	Clear and rounded	do	do	*Rotalina*, n. *Ehrenbergii*, Bailey. *Miliolina*, n. *seminulum*, W.
Bluish clayey silt, with lignite grains.	176 to 181	do	do	do	*Miliolina*, n. *seminulum*, var. *oblonga*, W.

Notes on the Lake Providence Reach borings.

(E. W. Hilgard.)

The most northerly of these, the Mayersville boring No. 1, does not differ in any way from those of the Choctaw Bar. Down to 30.1 feet the material seems to be entirely of the usual character of alluvium; thence to 118.6 feet the character is the same as elsewhere, first a stratum of finer sands, then gravelly sand and larger pebbles. These 88.5 feet undoubtedly belong to the older (Port Hudson) beds. Whether the brownish clay penetrated between 118.6 and 132.9 feet is of tertiary age, the data are not sufficiently definite to determine; but this seems to be the most probable conclusion.

Boring No. 2, the deep boring at Lake Providence town, is one of the most interesting, not only on account of the great depth reached (248 feet), and the great variety of materials encountered, but mainly from the fact that at this great depth the tertiary strata (contrary to the impression of the engineer in charge) have not been reached. The microscopic examination leaves no doubt on this point, the more as the examination of the lignitic clays of No. 3 showed definitely the presence of foraminifera and and therefore the connection of *that* material with the marine tertiary. In fact the materials of No. 2 form a complete epitome of those constituting the Port Hudson strata in the southern part of the Yazoo bottom, at the Port Hudson bluff, and on the sea-shore exposures at Côte Blanche and Weeks' Island.* The calcareous concretions and marly clays, supposed to indicate the tertiary age of the lower strata of No. 2, are extremely characteristic of the more southerly portion of the Port Hudson formation. The lignite found at 127.6 to 131.5 feet also differs materially in "ripeness" from that of the tertiary, as in Helena boring No. 1, sample 13. It is precisely similar to that found both at Port Hudson and on the Gulf shore, in the old quaternary deposits. The great thickness of the latter at Lake Providence indicates the deep erosion of the tertiary at that point, located probably in the line of the ancient main channel.

The upward limit of the Port Hudson materials, as against the alluvium, is difficult to draw at this point, in consequence of the great diversity of materials, and of the fact that in some cases the undoubted older deposits show no fossils. Since, however, the grains of lignite and carnelian spotted quartz occur at 42.9 feet, that depth must be assumed to be the maximum of the alluvium proper in No. 2.

In No. 2 A, close to the other, the alluvium evidently stops at 28.0 feet, the rest being the usual bottom sand and gravel beds.

No. 3, the boring at Hays' Landing, about 5½ miles southwest from No. 2, shows in its upper portion the same unusual variety of materials as No. 2. For that very reason it is extremely probable that if it were of the older formation the corresponding fossils would be easily found. The depth of the alluvium here may therefore probably be placed at 56.8 feet; from this depth to that of 109.0 feet there can be no doubt of the true character of the older or "bottom gravel."

Below the gravel lies the tertiary marl, with numerous but on the whole badly preserved fossils, recalling the aspect of the higher part of the Claiborne beds in eastern Mississippi, or that of the Jackson age on the Yazoo bluff near Satartia. From its geographical location and the imperfectly known southerly dip of the strata, either of the two stages of the marine tertiary might here be looked for. Unfortunately these are so few in number as not to allow of very positive conclusions. Those identified with more or less certainty are the following:

Leda media Lea? *Leda plicata* Lea? and another species; *Venericardia rotunda*, *V. transversa?* Lea, the latter identical with that found at Choctaw Bar; a *Turbinolia*, and a species of *Lunulites*, not described by Lea; a fragment of a *Tellina*.

The *Ledas* are foreign to the Jackson group, from which only the very distinct *Leda multilineata* is known. *Venericardia rotunda* belongs to both the Jackson and Claiborne beds, but nothing resembling *V. transversa*, or the fossil here observed, occurs in the Jackson beds. On the other hand, the leading fossils of Choctaw Bar and Helena—the *Dentalium* and the *Naticas*, as well as the *Otolites*, are here wanting. It is therefore probably one of the higher divisions of the Claiborne age, separated from the one occurring above by the partly lignitic beds here underlying; a feature of such common occurrence in Western Mississippi and Louisiana that it is rather the rule than an exception. The microscopic organisms confirm the view that while the bed has strong affinities in the direction of the Choctaw Bar and Helena beds, yet it is somewhat distinct in the occurrence and especially in the predominance of species.

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*See the writer's memoir, No. 248 of the Smithsonian Contributions to Knowledge.

LIST OF LARGER FOSSILS.

[From the borings at Choctaw Bar, Helena, and Lake Providence Reach.]

	Choctaw Bar, No. 2.	Helena, No. 2.	Lake Providence, No. 2.	Remarks.
VERTEBRATA.				
Otolites	Abundant.	Abundant.		
BIVALVES.				
Leda media, Lea?			1	Specimens too fragmentary to be definitely identified, but all distinct from *Leda multilineata* of Jackson.
Leda plicata, Lea?			1	
Leda			1	
Nucula magna, Lea		1		A small fragment of anterior end, but well defined.
Venericardia planicosta	1			
Venericardia rotunda, Lea	1		1	Very young specimens, but well characterized.
Venericardia transversa. Lea	1		1	Fragments too indefinite, but perhaps a distinct species.
Corbula Murchisoni, Lea	1			Lea's figures and descriptions of *C. gibbosa* and *compressa* leave a doubt between them when the anterior portion is wanting; perhaps all those marked *C. gibbosa* should be assigned to young of *C. Murchisoni*.
Corbula gibbosa, Lea	4			
Corbula compressa, Lea?	4			
Lucina papyracea, Lea?	1	2		Probably the young of *L. papyracea*, Lea.
Tellina			1	A very smooth-surfaced species, too fragmentary for specific identification.
Cardium	8			Shell thin and ribs triangular; not ornate.
UNIVALVES.				
Dentalium turritum, Lea, or	Abundant.	Abundant.		Smaller than Heilprin's type from Wood's Bluff, but not otherwise distinct
D. microstriatum, Heilpr				
Natica, minima, Lea	2	3?		Several imperfect specimens seem referable to this species
Natica magno-umbilicata, Lea	Abundant.	Abundant.		Well preserved except mouth; leave some uncertainty.
Orbis rotella, Lea?	1			A doubtful fragment of body whorl.
Pleurotoma Lonsdalii, Lea		1		The specimens are small and often much worn, so as to render identification difficult without direct comparison with originals.
Pleurotoma Childreni, Lea	1			
Pleurotoma Beaumontii, Lea	1			
Pleurotoma	1	1		
Pleurotoma	1			
Fusus pagoda, Heilpr	1			In the absence of the canal, mostly wanting, these species are difficult of identification.
Fusus magnocostatus, Lea?	1			
Fusus	1			
Fusus	1			
Pyrula	1			Spire only, not identifiable.
Pyrula	1			
Turritella plebeia, Say	8			Young specimens, but hardly doubtful.
Turritella Mortoni, Con	2			
Buccinum	8			
Actæon lineatus, Lea	8	1		Well-preserved specimens of all.
Actæon ponilius, Lea	1			
Actæon pygmaeus, Lea	1			
Nassa cancellata, Lea	2			Fragments, but characteristically marked.
Alletha Tuomeyi, Con	1			Part of body whorl, quite definite.
Cancellaria	1			Near *parva*, Lea, but spire lower.
Mitra	1			
Oliva gracilis, Lea	1			Complete specimen.
Monoceros vetustus, Lea	1?	8		One specimen almost complete; that from Choctaw Bar doubtful.
CORALS.				
Flabellum		1	1	Not described by Lea.
Turbinolia				Indefinite cast in a piece of marl.
Lunulites			2	Not described by Lea.
Retepora?		1		Do.

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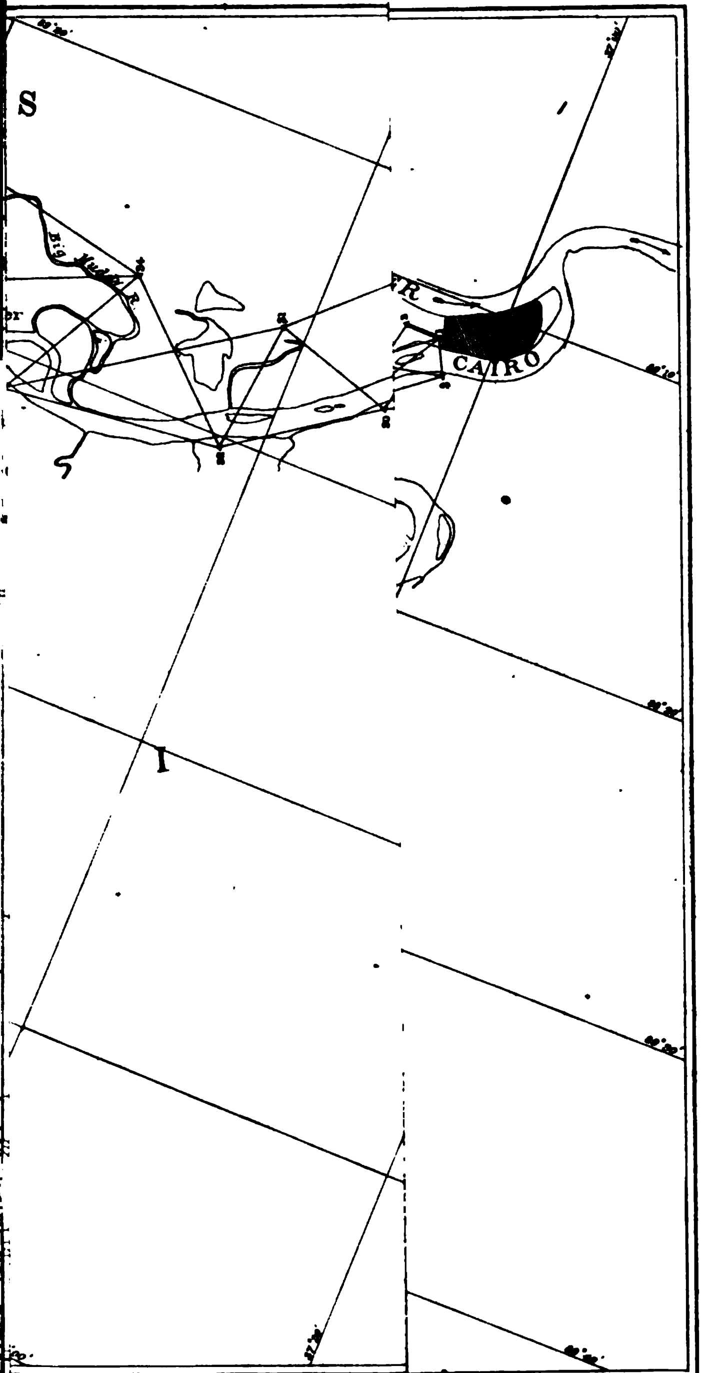

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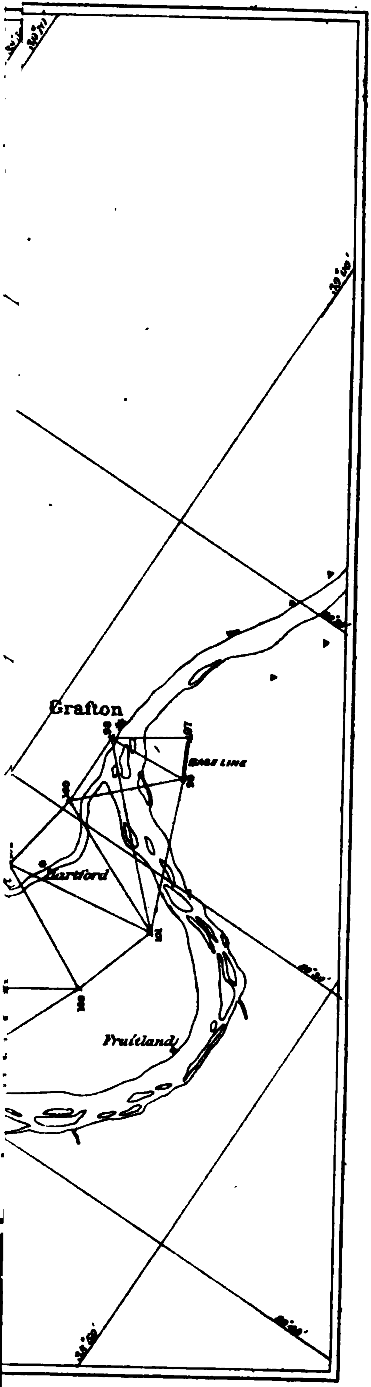

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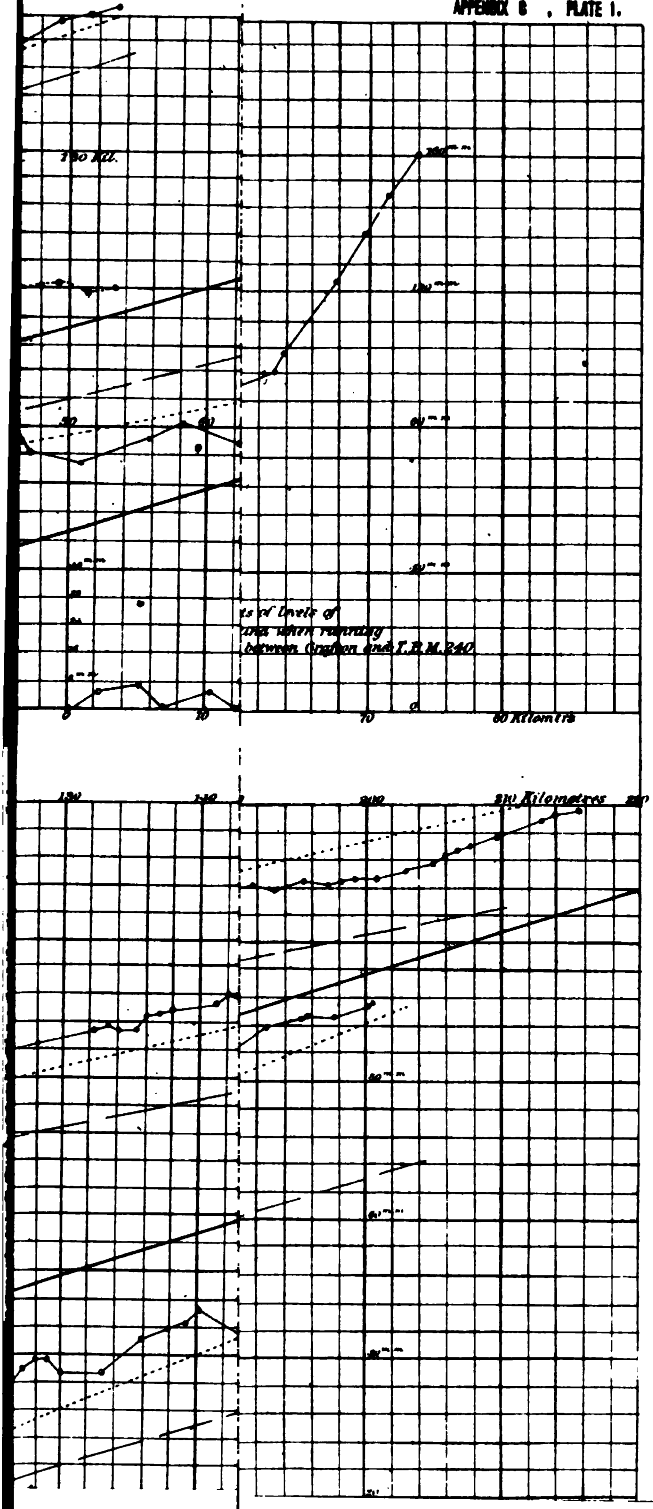

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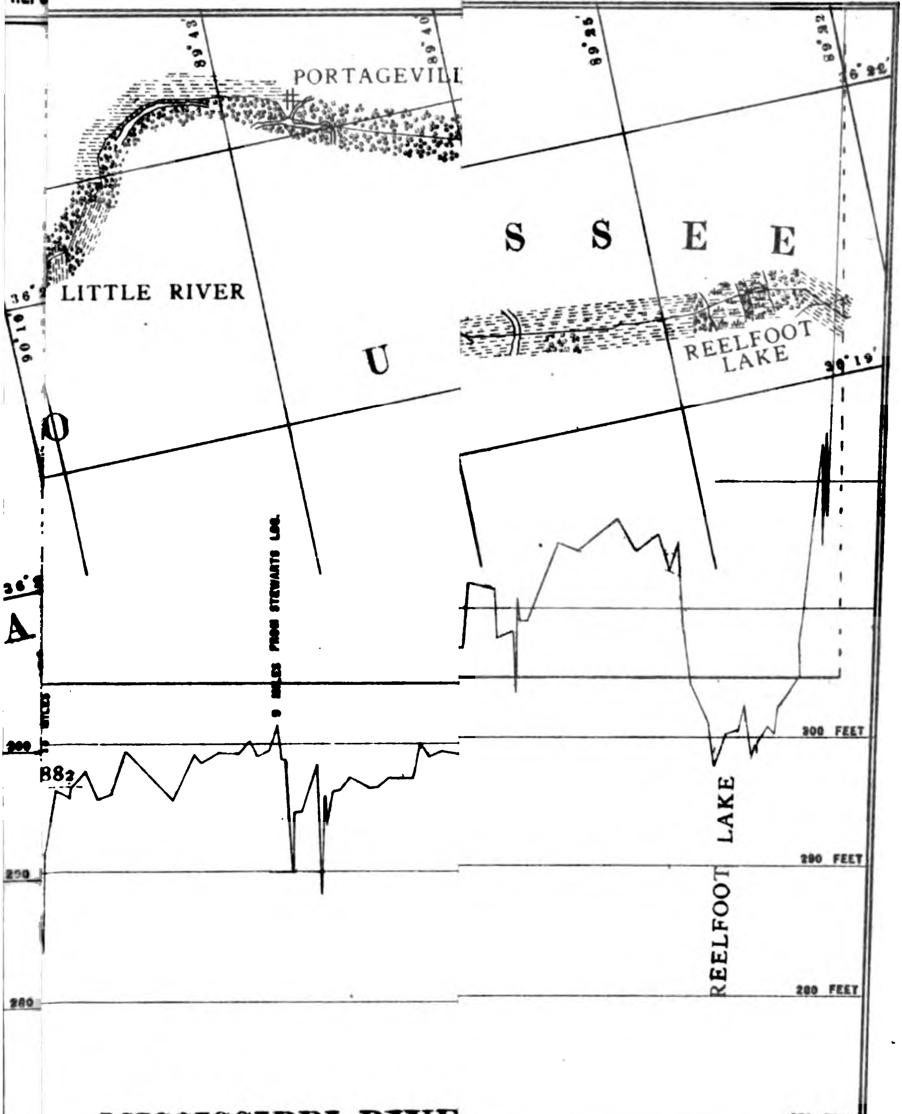

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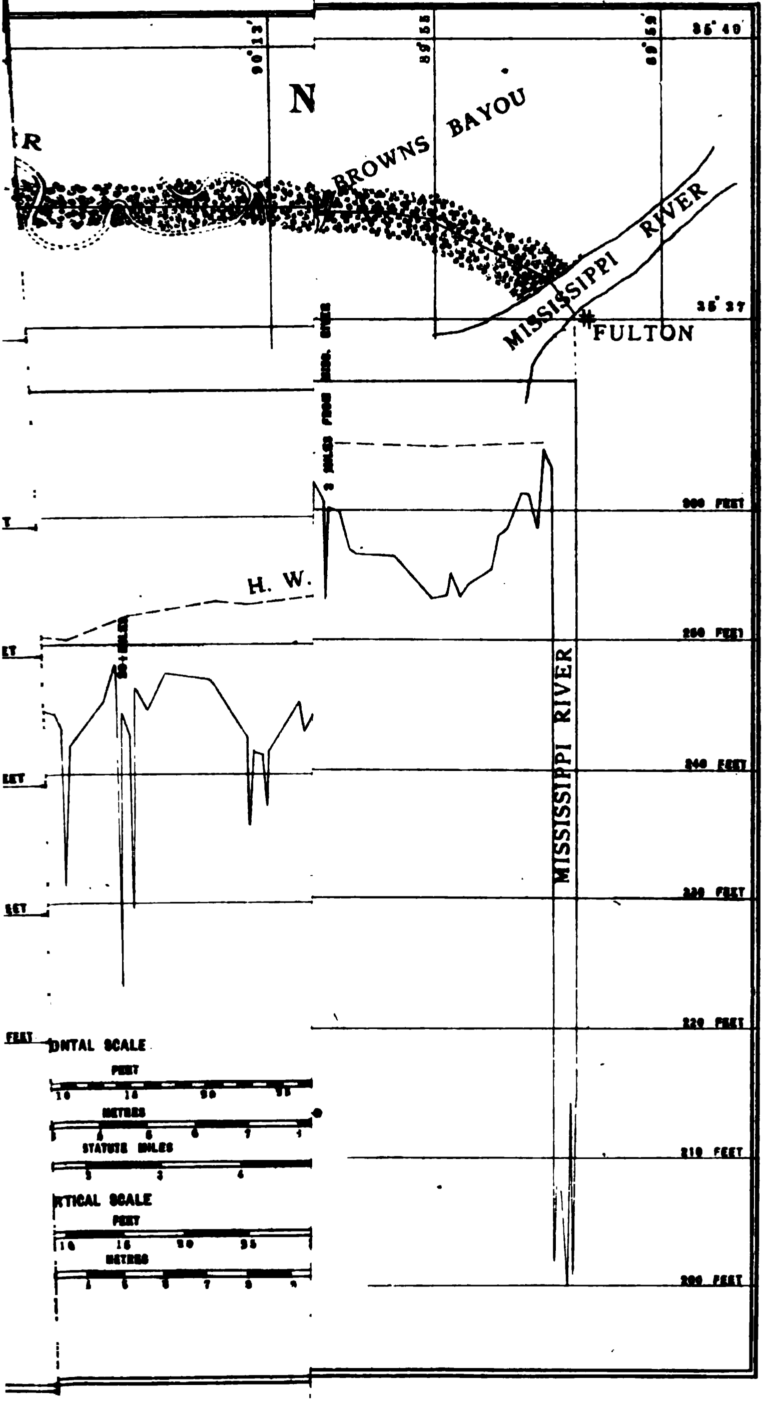

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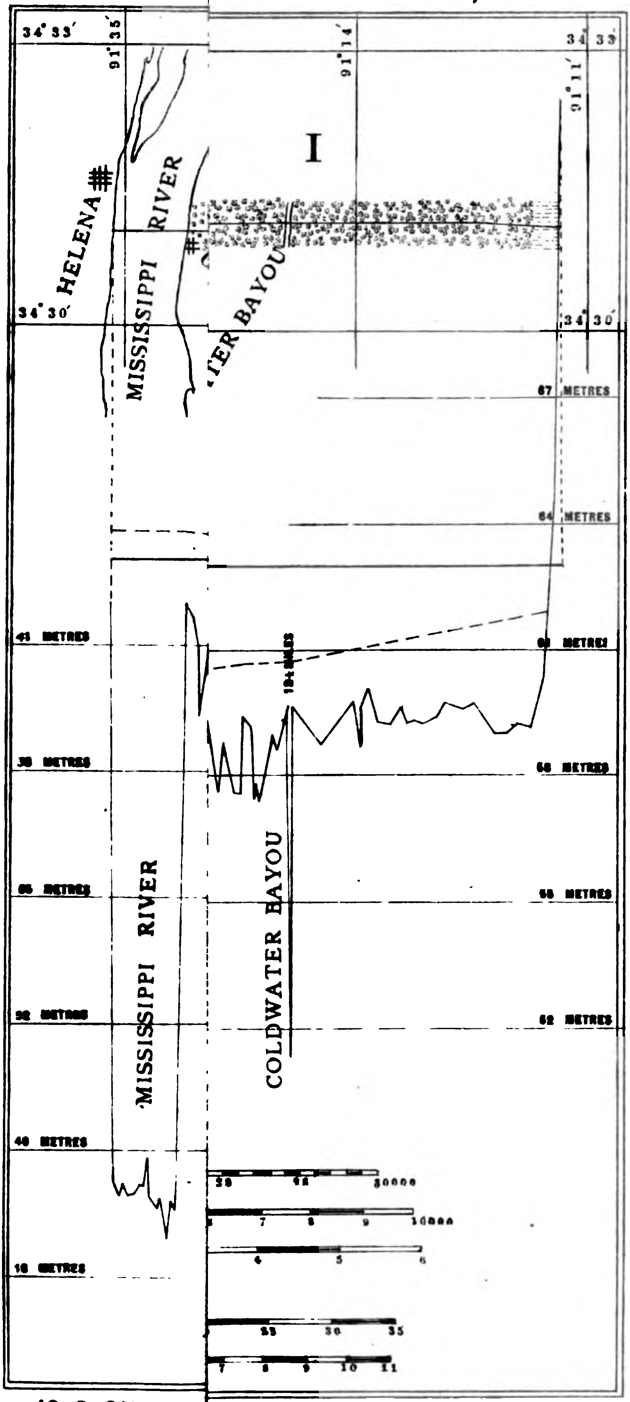

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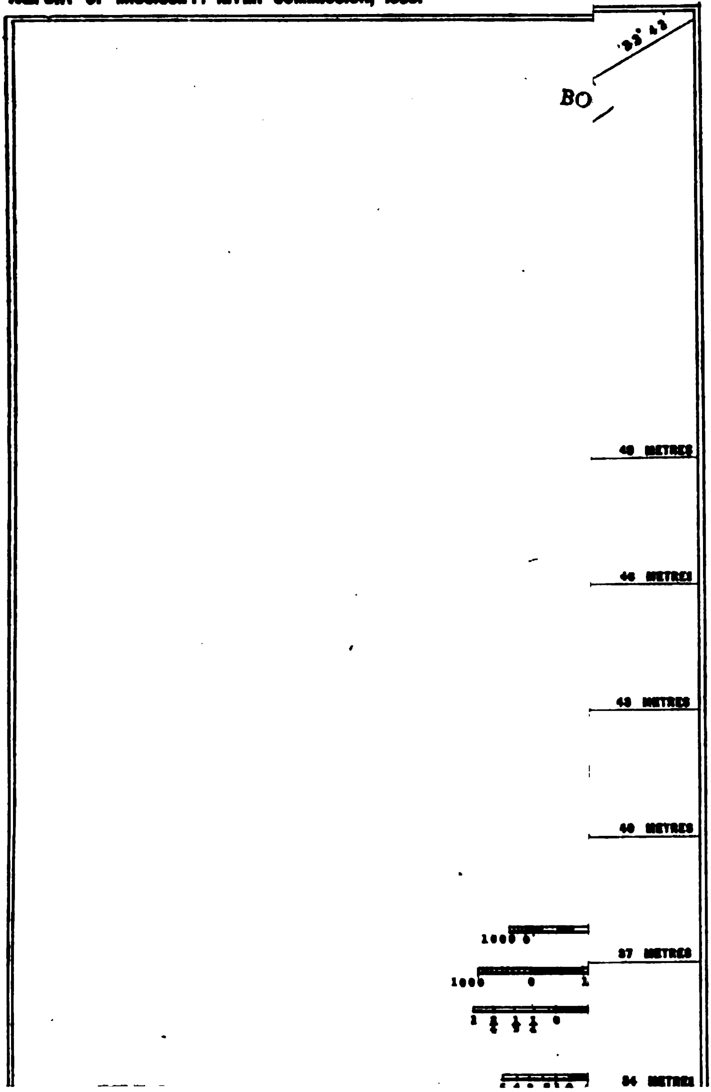

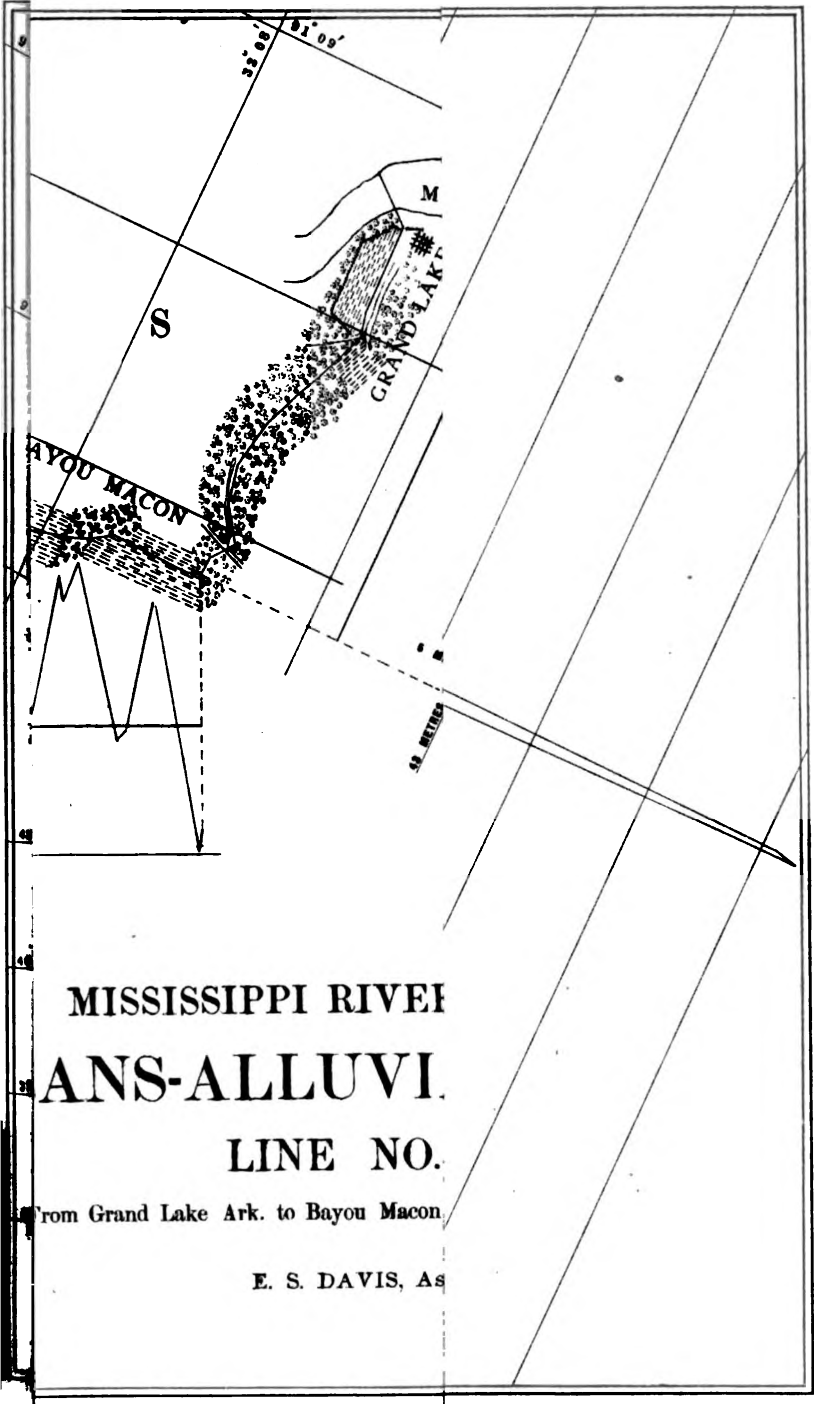

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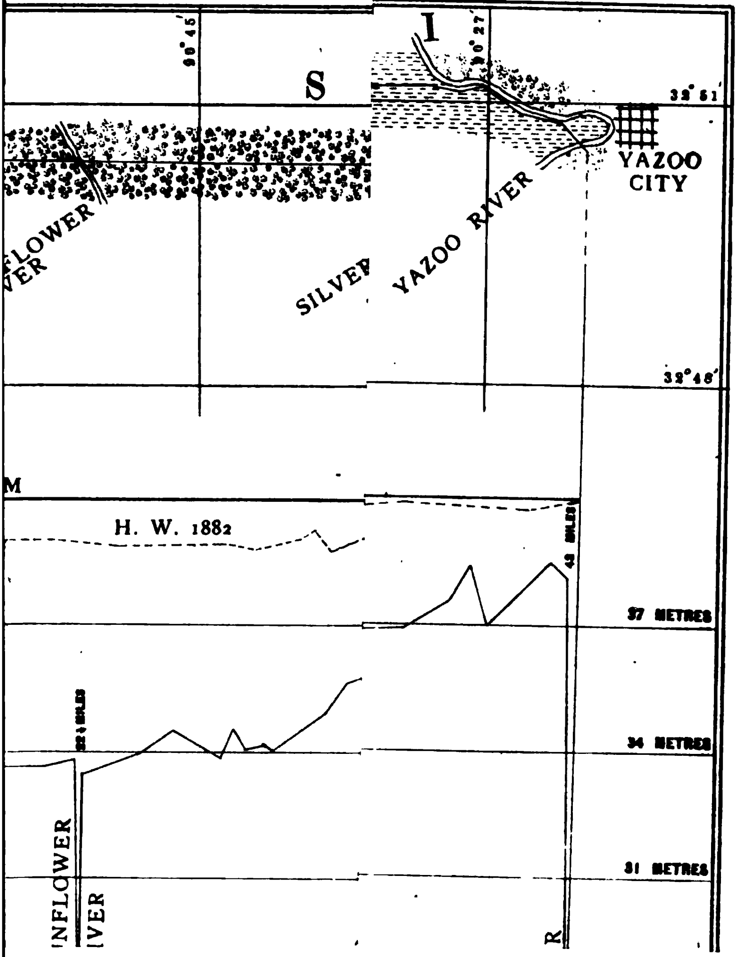

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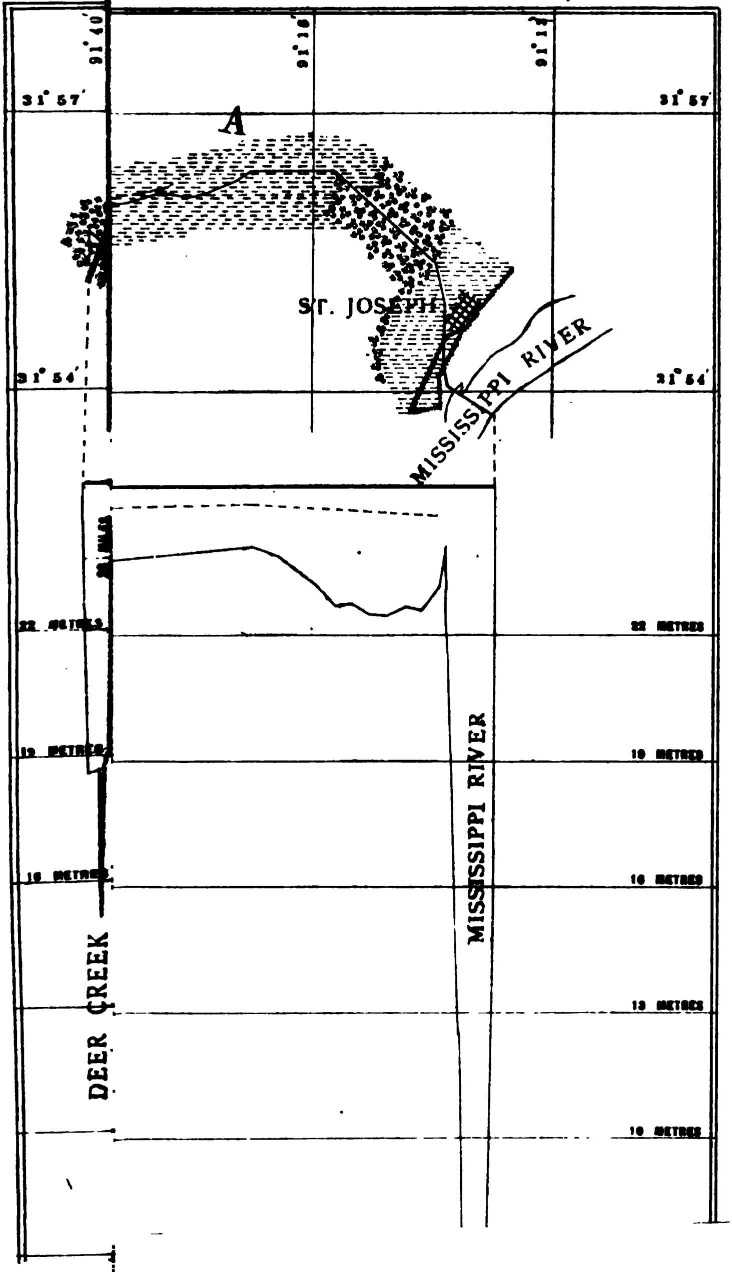

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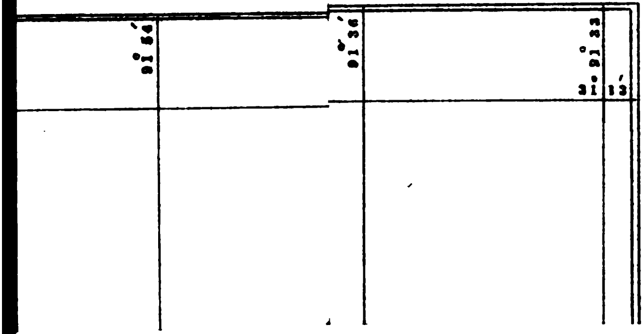

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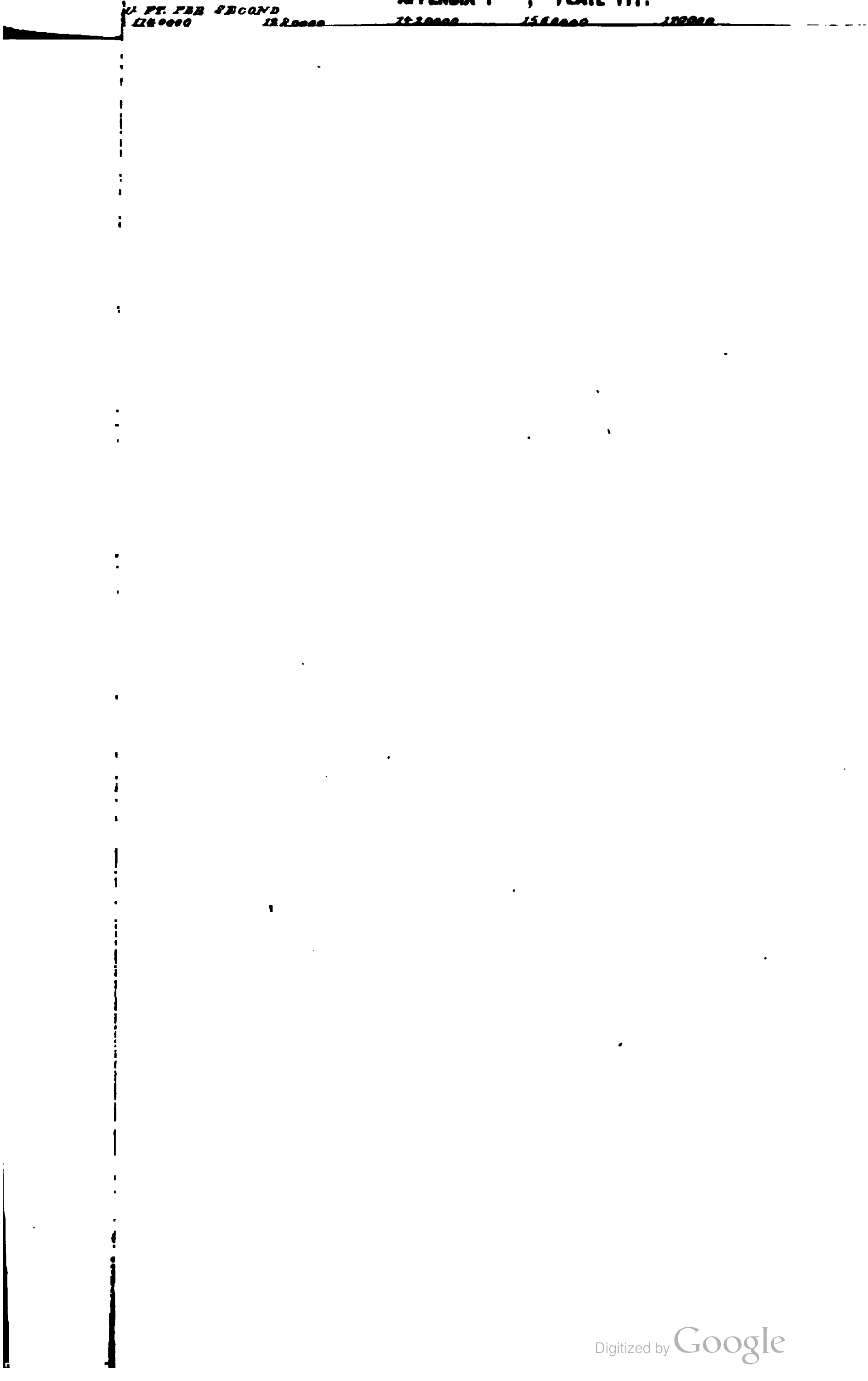

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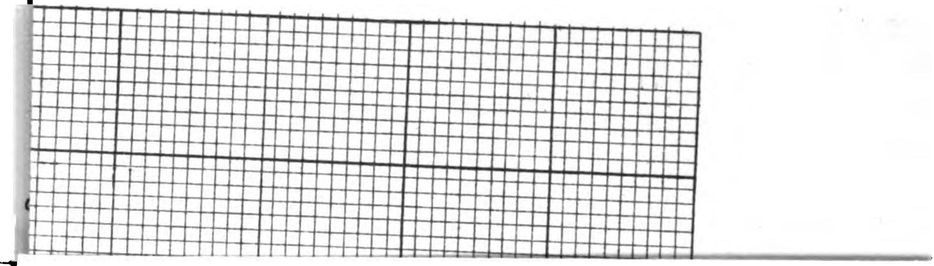

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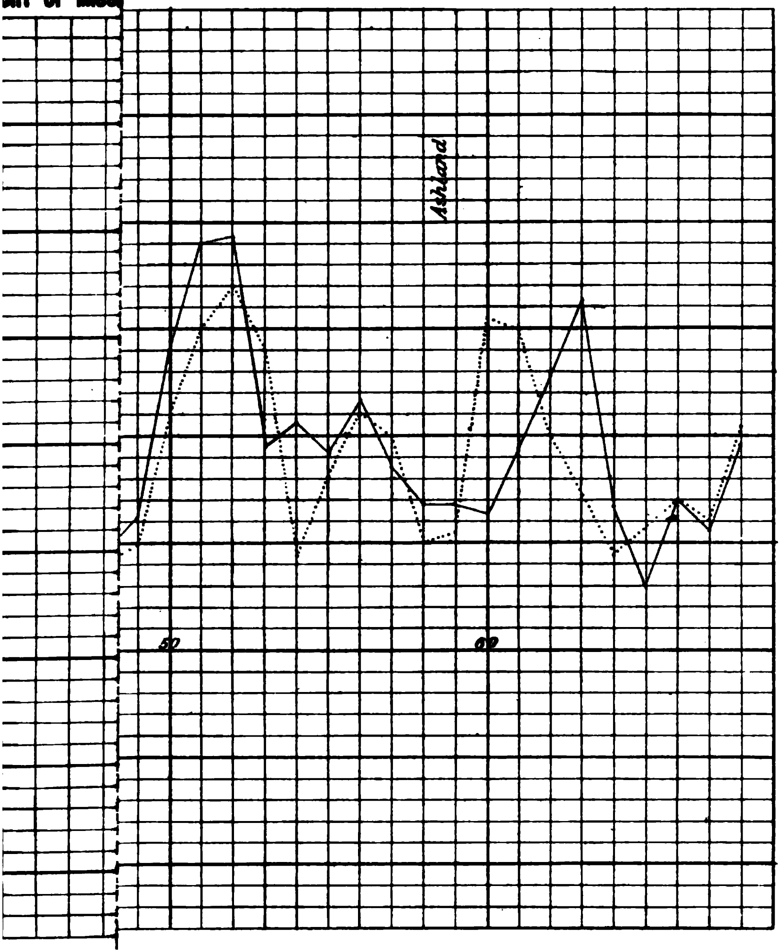

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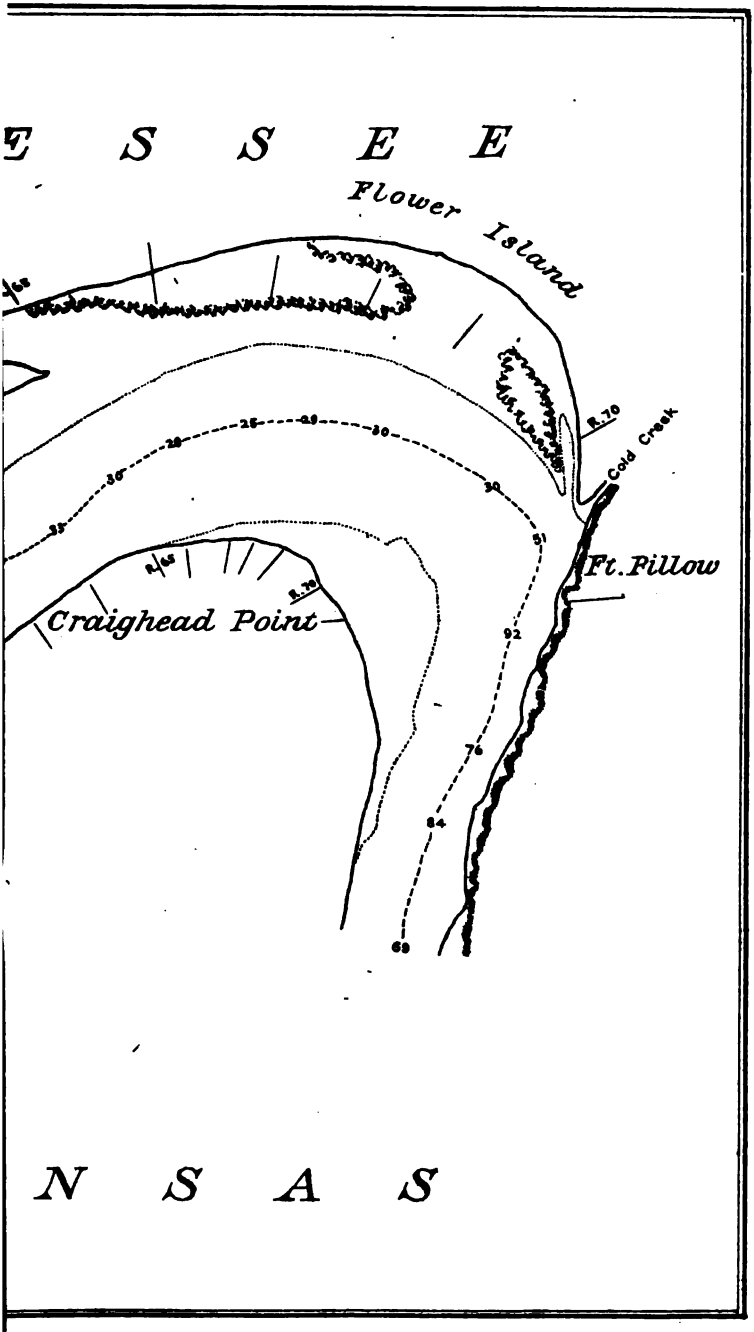

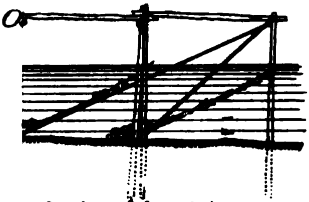

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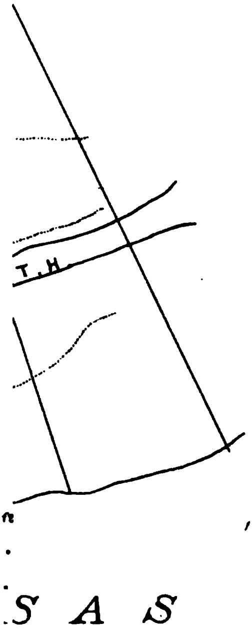
═	Dykes Comple
·······	do. in bad
▬	Foot Mat Sunk
- - - - - -	Wattling
▮▮▮	Grillage Foot Mat S
═ ┄┄	Dyke to be comple

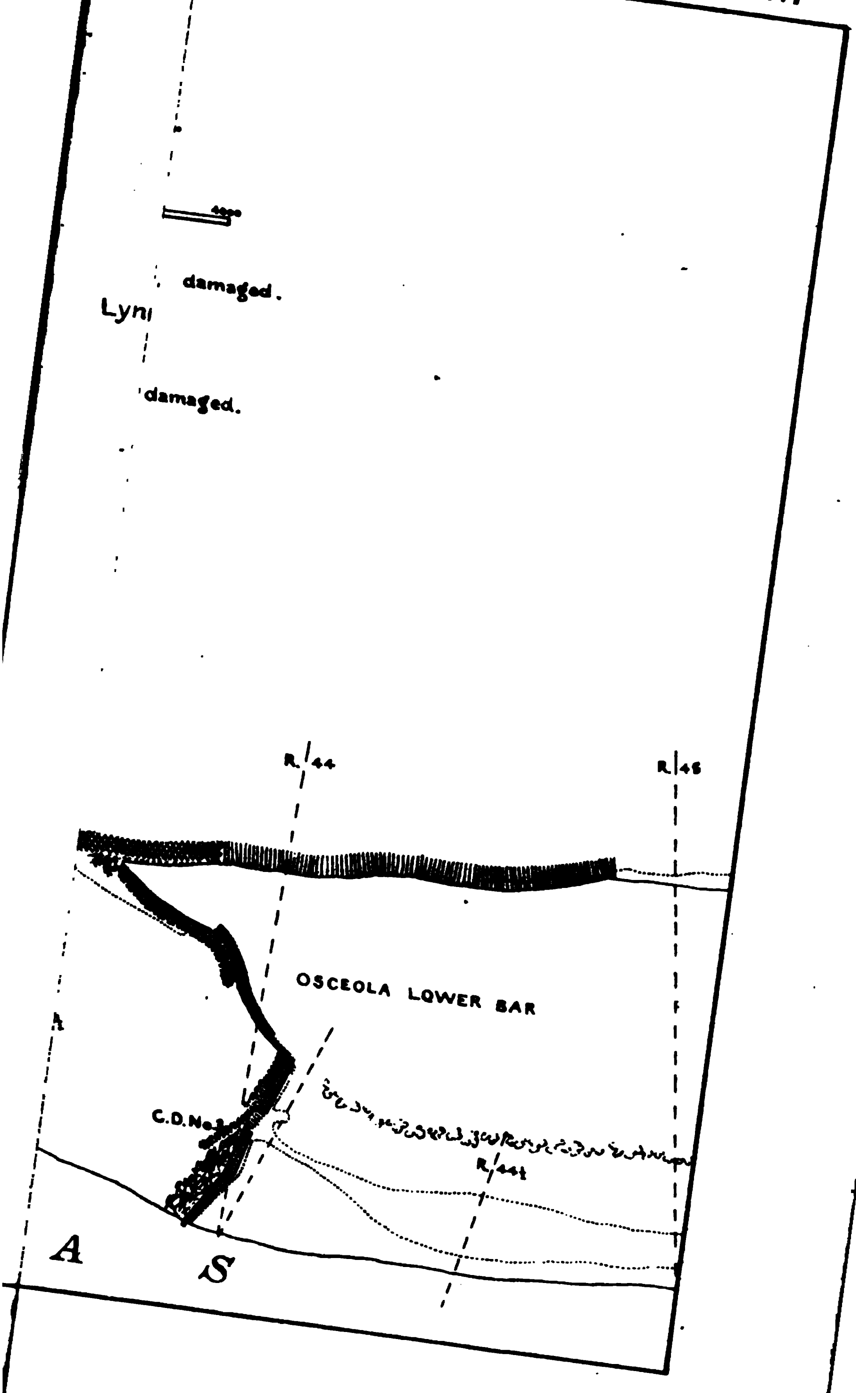


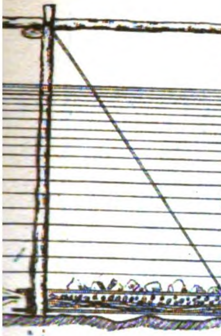
LENGTH OF DYKES.

O.-B. Main, completed.	3754 ft
do. do. opening,	900 "
do Cross No 1, completed,	1770 "
do do opening,	630 "
Plum Point Main, completed,	450 "
do Cross No.1, do.	351 "

REPORT

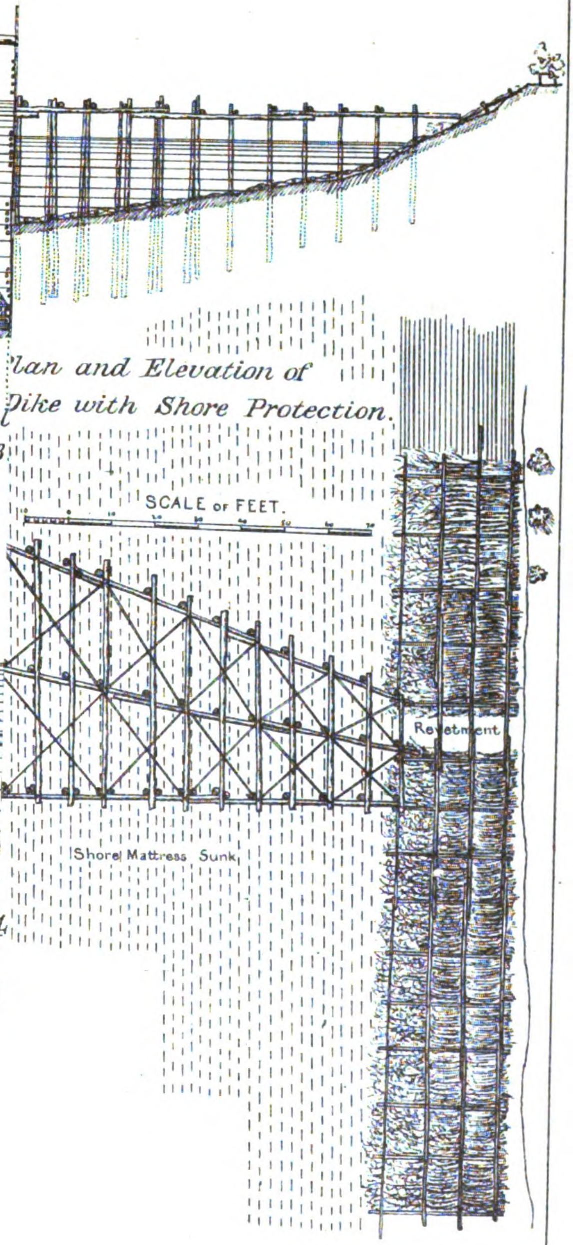
APPENDIX J, PLATE IV.



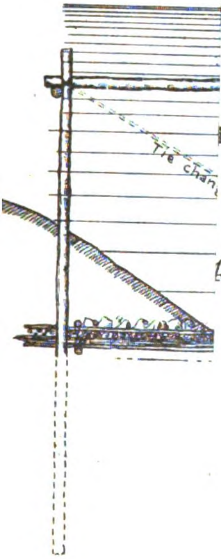


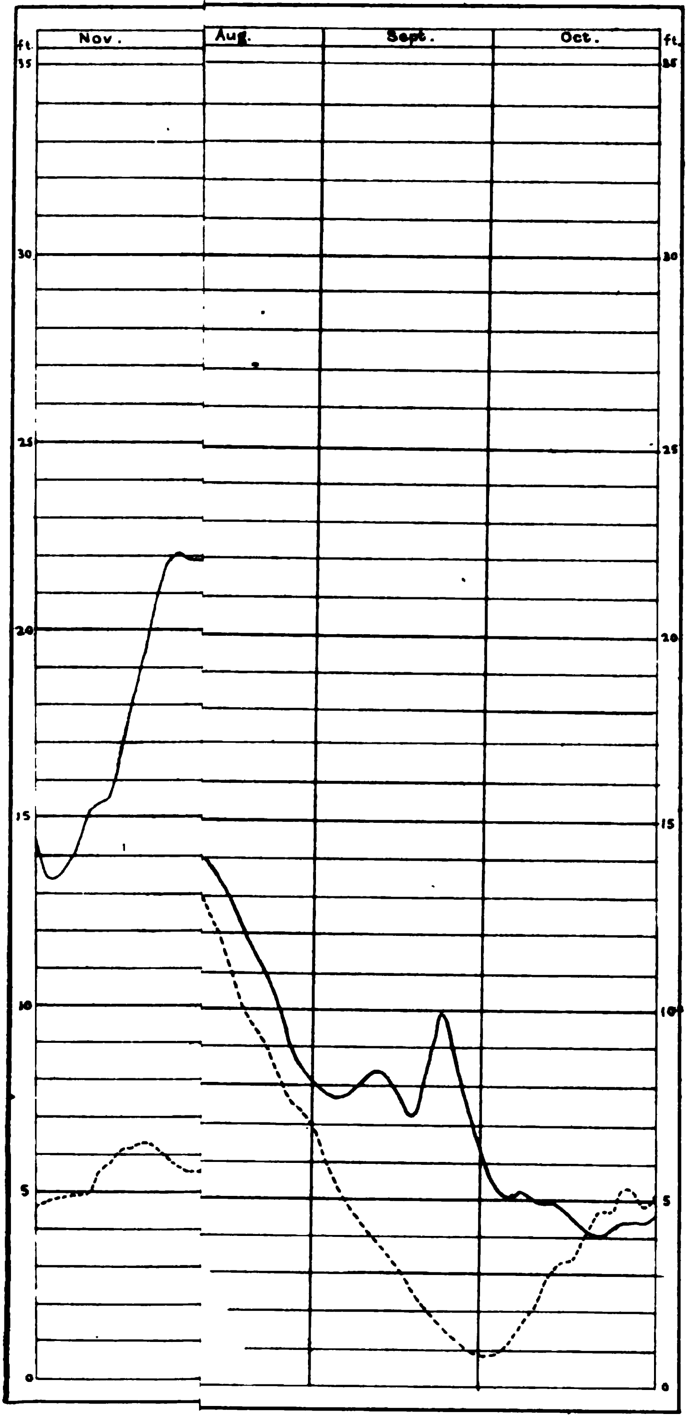
1

Section of Pil
Jan '83

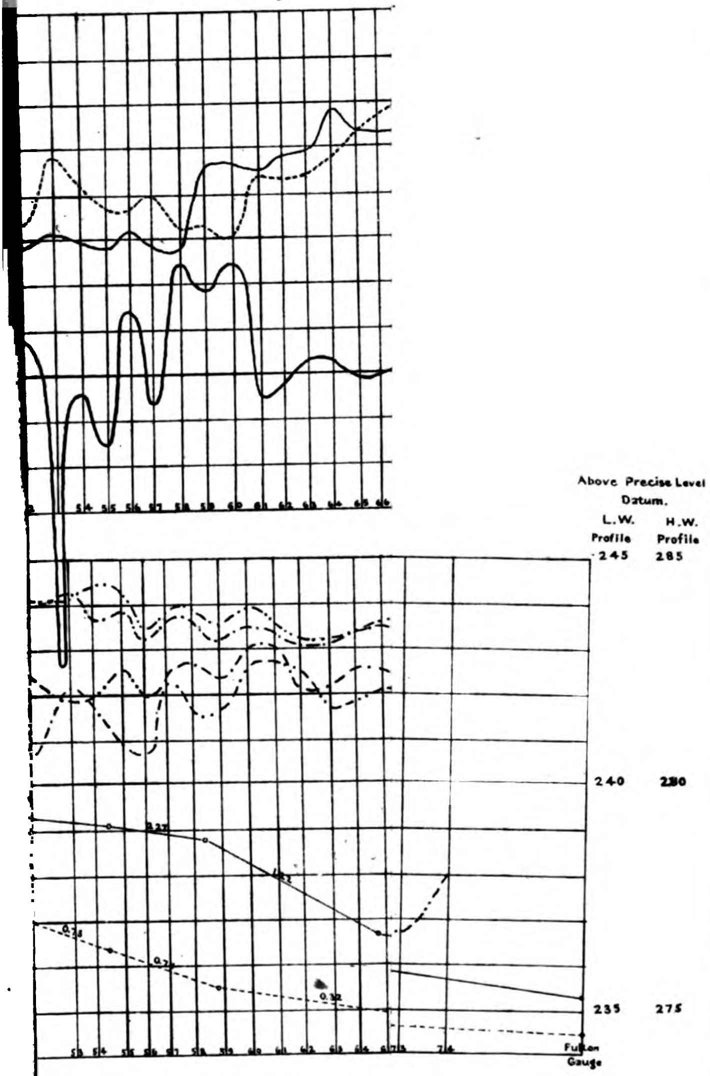


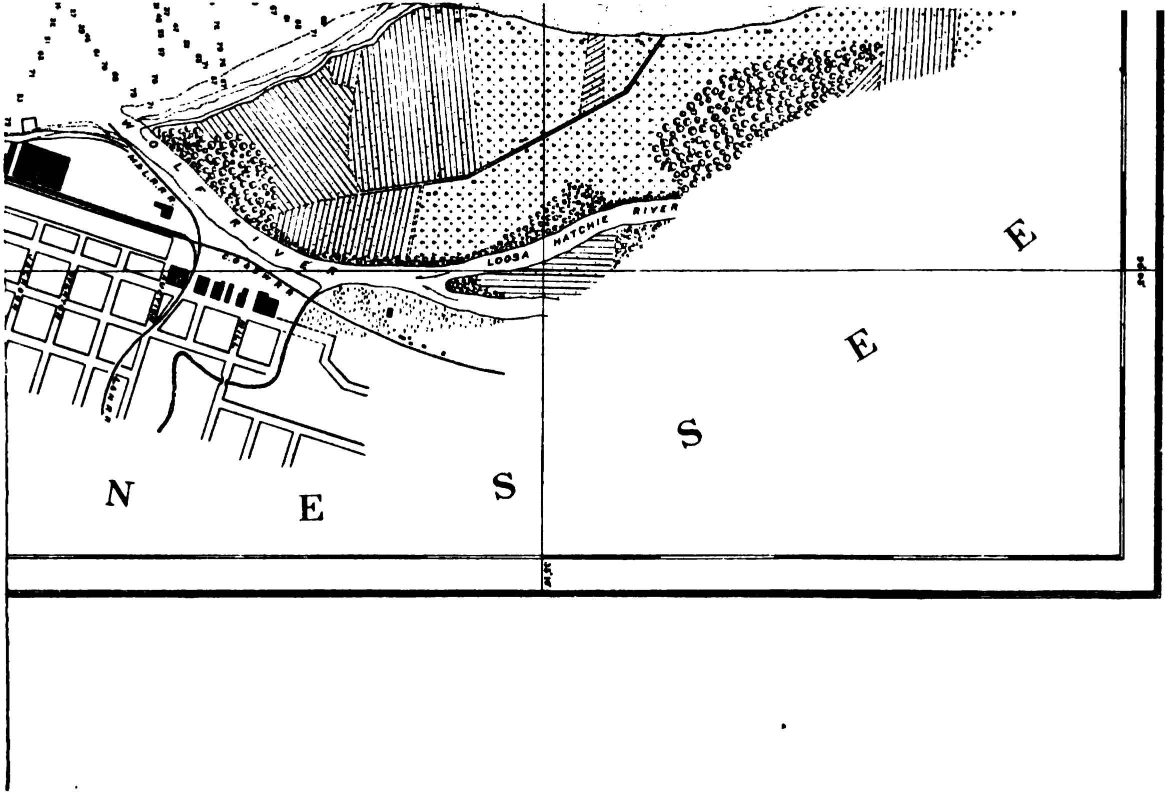
lan and Elevation of
Dike with Shore Protection.



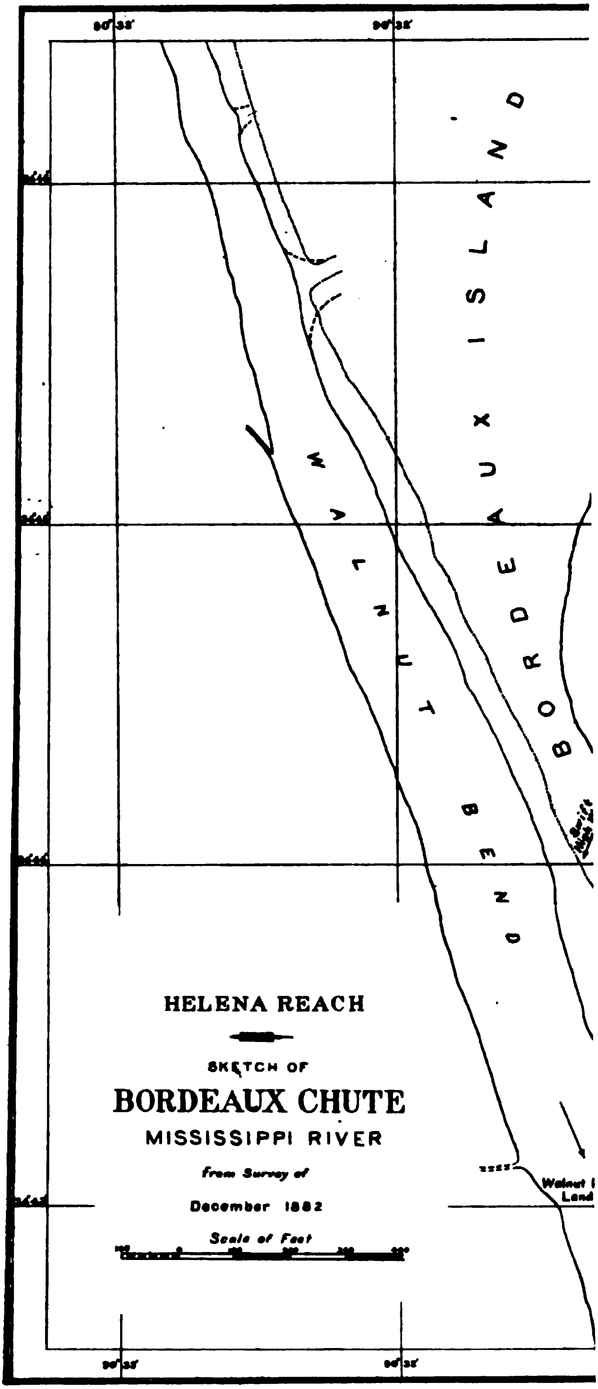


48 2 CH EN


54
55
56
57
58
59
60
61
62
63
64
65
66
Above Precise Level Datum.
L.W. Profile
H.W. Profile
245
285
240
280
235
275
0.27
0.22
0.33
0.27
0.32
53
54
55
56
57
58
59
60
61
62
63
64
67
75
74
Fulton Gauge


NESSEE
LOOSA HATCHIE RIVER
WOLF RIVER

REPORT OF MISSISSIPPI RIVER COMMISSION, 1883.



HELENA REACH

SKETCH OF

BORDEAUX CHUTE

MISSISSIPPI RIVER

from Survey of

December 1882

Scale of Feet

48 2 CH ENG

APPENDIX L , PLATE I.

PLATE. I.

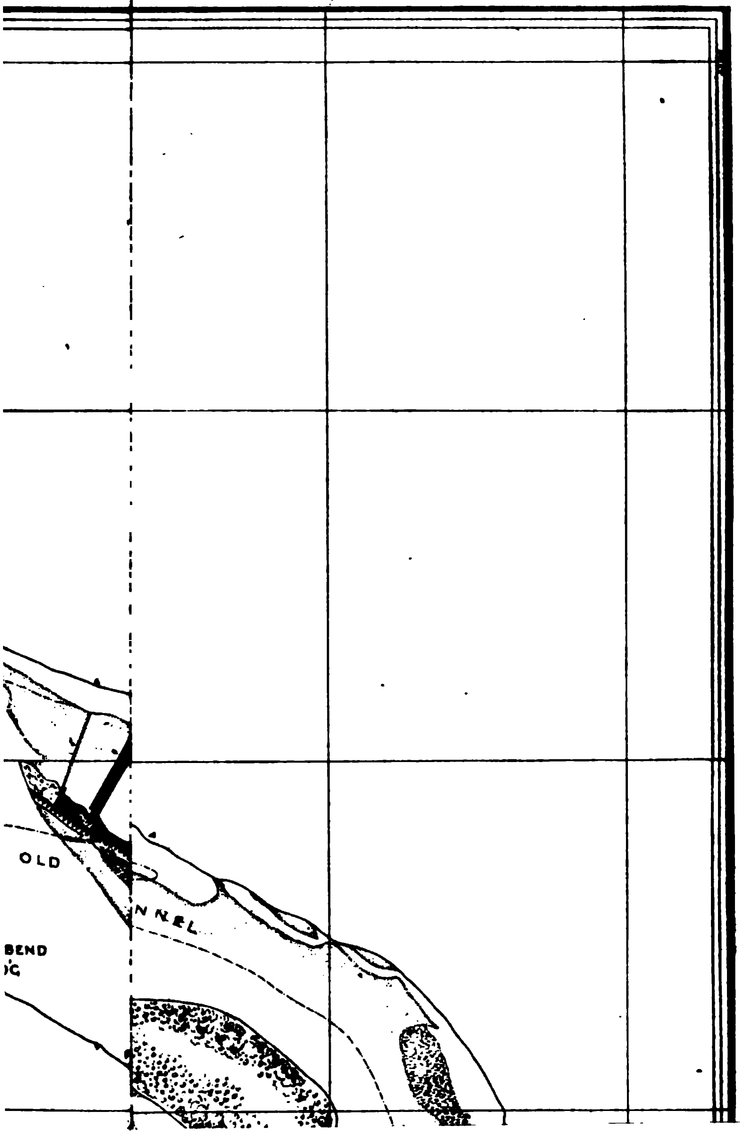
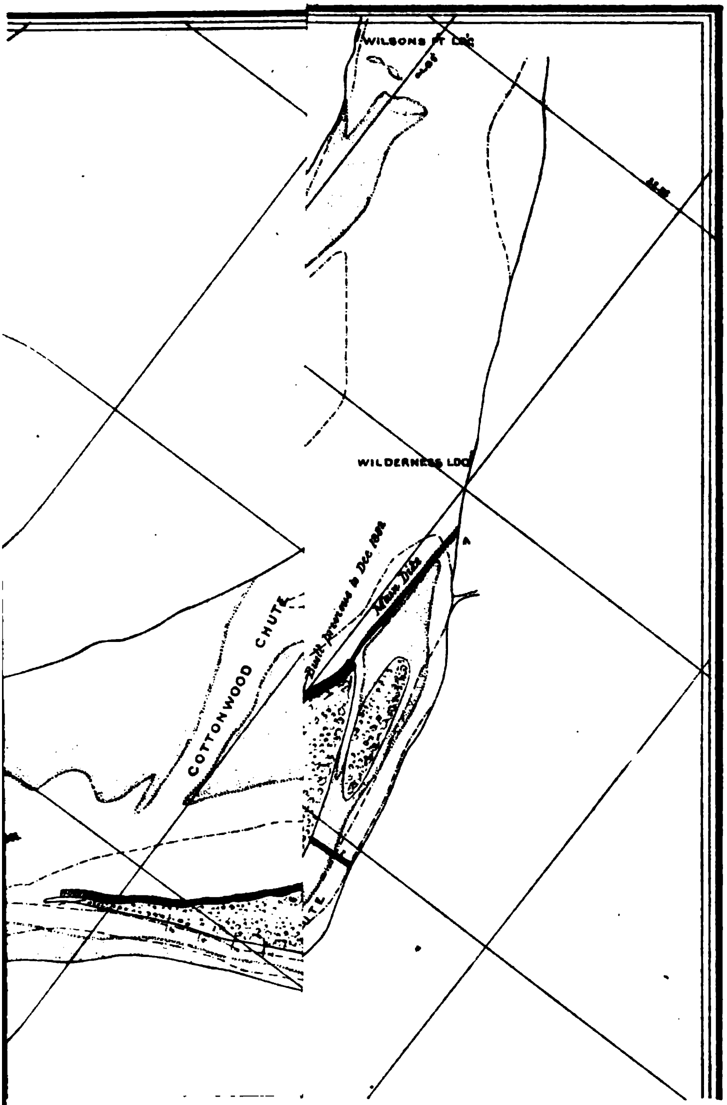
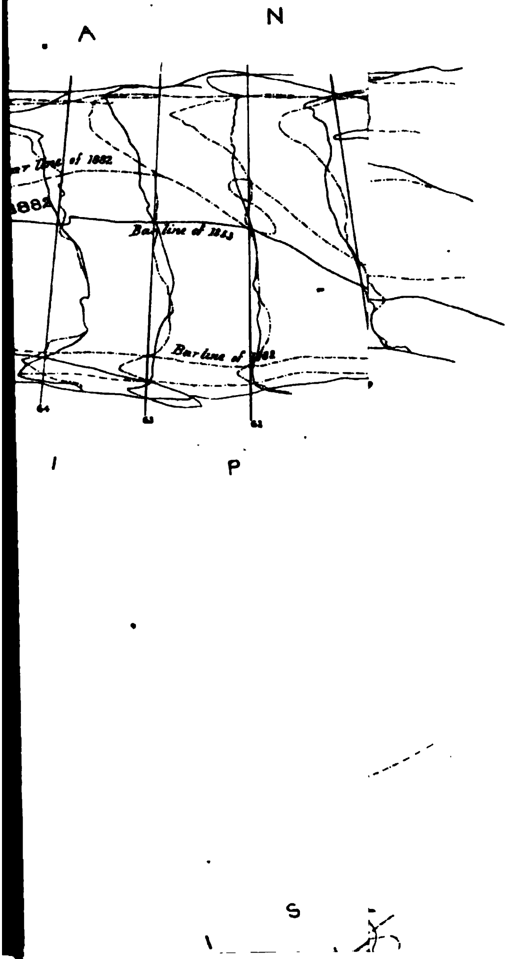


PLATE. II.



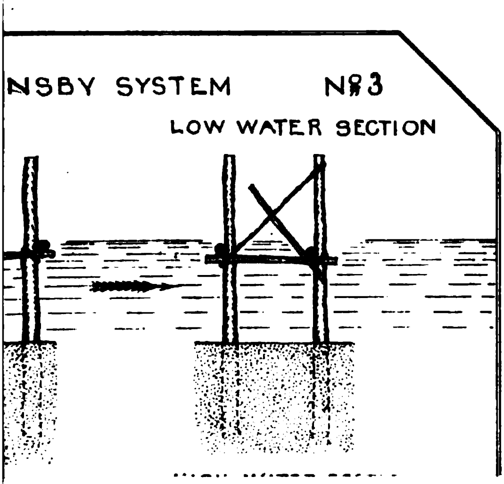
WILSONS PT LDG
WILDERNESS LDG
COTTONWOOD CHUTE
Built previous to Dec 1882
Main Dike
A
UTE

PLATE Nº III.


A
N
r Line of 1882
1882
Bar line of 1883
Bar line of 1882
64
63
62
I
P
S

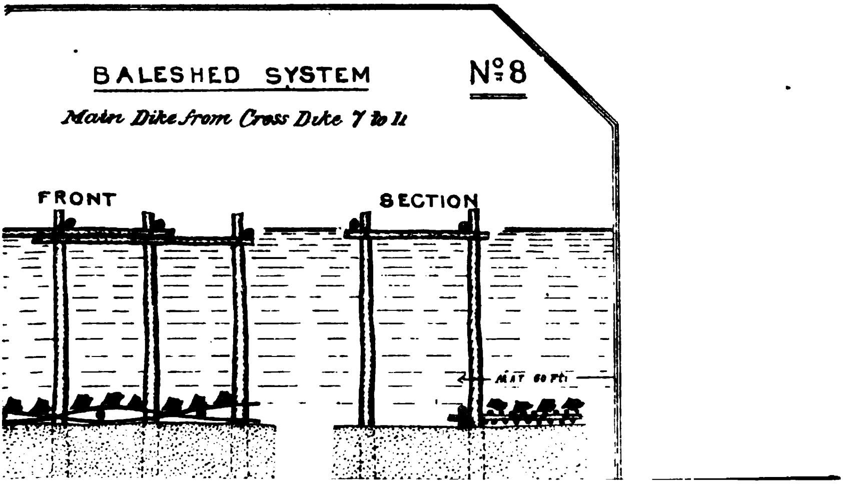
APPENDIX L , PLATE. IV.

PLATE Nº IV.



APPENDIX L, PLATE V.

PLATE No. V.

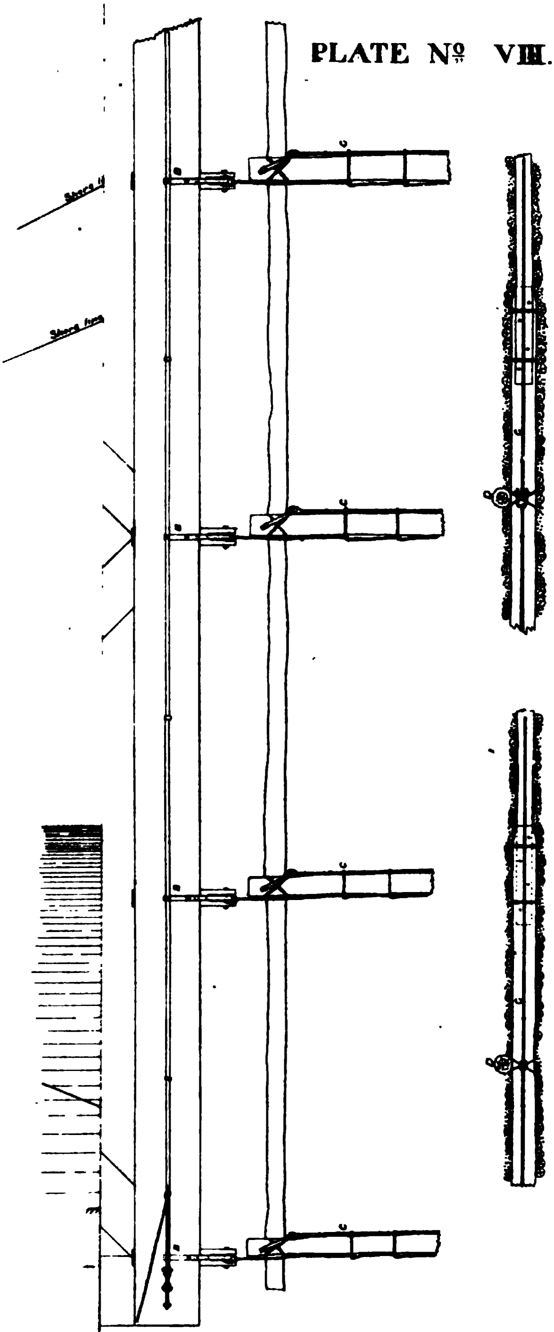


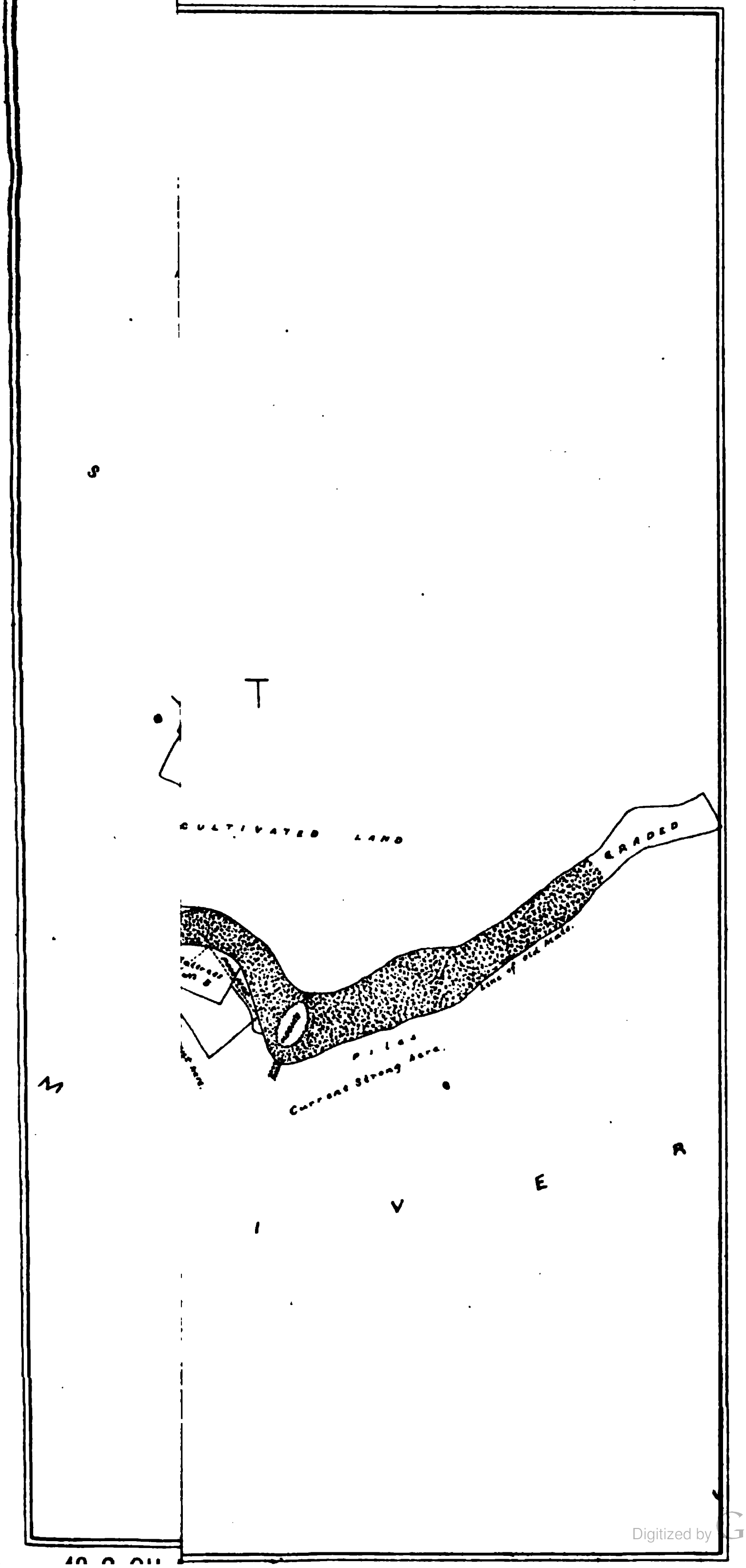
APPENDIX L , PLATE VI.

PLATE Nº VI

REPORT APPENDIX I. PLATE VII.

PLATE Nº VIII.




S
T
CULTIVATED LAND
GRADED
Line of old Mole.
Piles
Current Strong here.
M
I
V
E
R

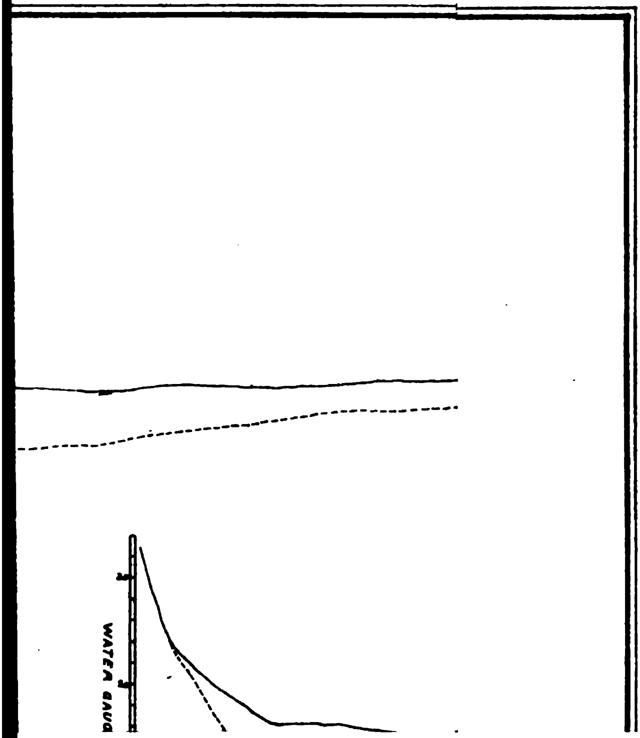
APPENDIX L. PLATE XI.

APPENDIX L . PLATE XII.

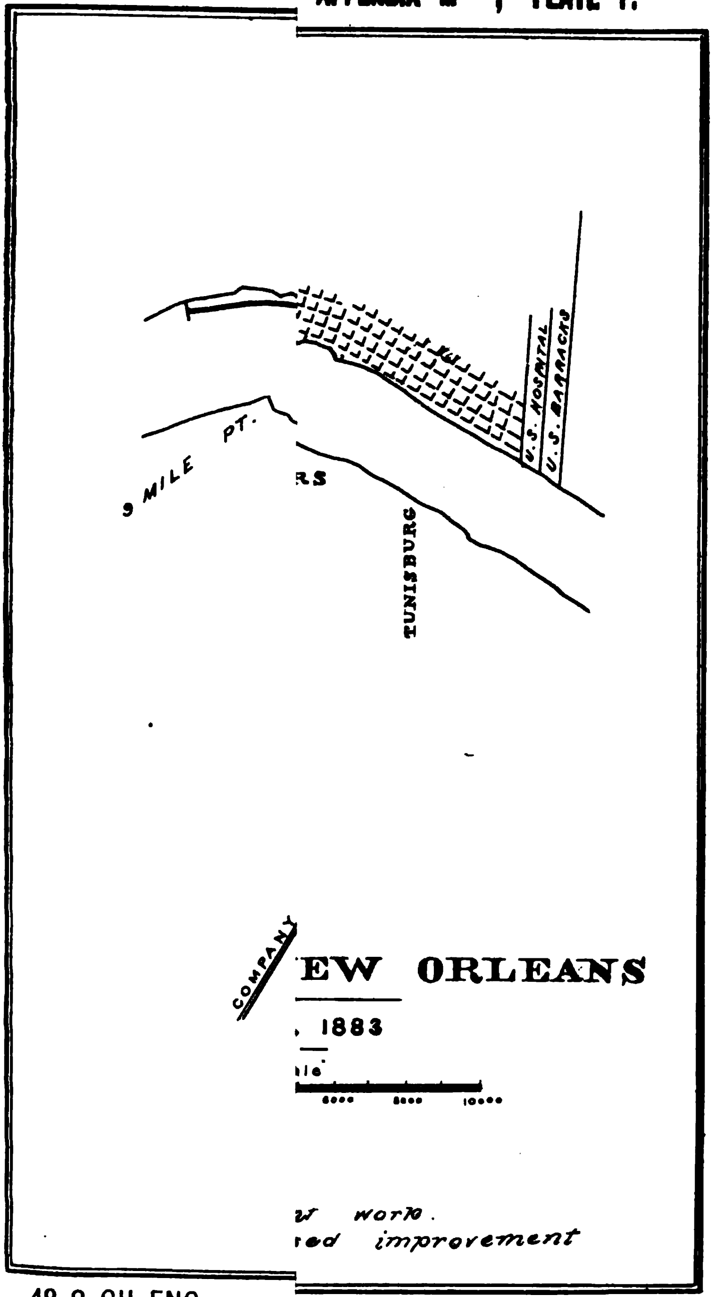
TION.

BOR.

APPENDIX L. PLATE XIII.

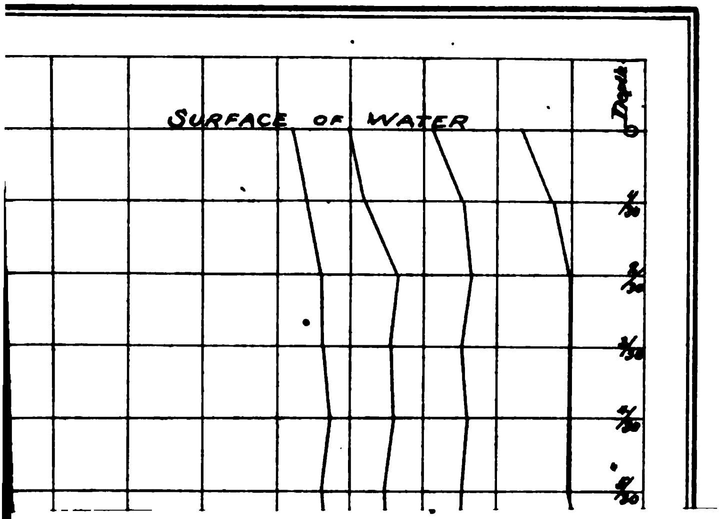


REPORT OF MISSISSIPPI APPENDIX M , PLATE I.



48 2 CH ENG

APPENDIX M , PLATE II.



APPENDIX M. PLATE III.